



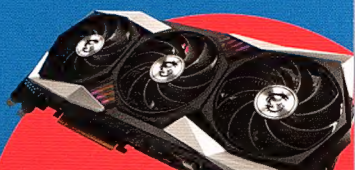
apoc

SINCE 1980

JULY 2022 #508 | YOUR EXPERT GUIDE TO TODAY'S TECH

THE WORLD'S MOST ICONIC PCs

From the first Apple Mac to the Xerox Alto



HAS AMD REDEFINED VALUE?

Radeon 6400, 6650 & 6750 affordable gamer cards tested

WRIST RELIEF

Logitech's pain-free vertical mouse hands-on

GRAPHICS CARD BUYER'S GUIDE

BUDGET TO EXTREME & EVERYTHING IN BETWEEN



NVIDIA

VS



AMD

CAN INTEL'S ARC MAKE IT A 3-WAY CHOICE?

PLUS

- BEST LAPTOP INTEGRATED GRAPHICS
- RAY TRACING WITHOUT THE FPS HIT
- BEST GAME GRAPHICS SETTINGS
- WHAT YOU NEED FOR 4K

AN A RASPBERRY i BE YOUR VERYDAY PC?

ffer with us as e test this madness actually worked!)

TURE L F



07

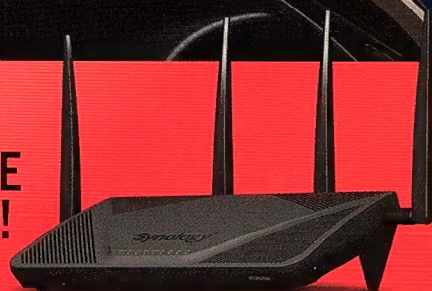
AUS\$10.95 INC GST NZ \$10.90 INC GST
PRINTED IN AUSTRALIA
ISSN: 0725-4415

ADVANCED WINDOWS 11

Registry editor pro-tweaks
PLUS Take control of Windows Update

THE BEST ROUTER WE'VE EVER TESTED!

Synology RT6600ax



GIGABYTE | intel.



NVIDIA® GeForce RTX™ 30 Series Laptop GPUs
12th Gen Intel® Core™ i9 / i7 Processor H-Series
3mm 4-side Super Narrow Bezel
4K UHD MiniLED Panel
World's First Microsoft Azure AI Notebook

Elevate Your Vision

AERO 16 / 17 Creator Laptops
12th Gen Intel® Core™ i9/i7 Processor



The brand new AERO series laptops elevate your vision with the gorgeous 16:10 4K OLED & Mini LED display, delivering super wide color gamut, strong HDR capability and the most accurate color reproduction. Combined with the INTEL 12th gen 14-core CPUs and Thunderbolt 4, AERO presents the ultimate laptops for all creators.

Full GIGABYTE 12th gen gaming & creator laptops check here





SUBSCRIPTION ENQUIRIES

(02) 8227 6486
www.techmags.com.au
future@crmaus.com.au

INTRO

EDITORIAL

WHAT'S INSIDE APC



EDITORIAL

Ultimate eye candy

Nice things we can finally afford.



BEN MANSILL
has an 11900K + 3080Ti for his sim racing rig, and a 5950X + 3080 for his desktop PC.

"With our guide you'll know the GPU to shoot for and can jump on the best deal when it's time to buy."

It's finally time – albeit with some caution in reserve – to declare the GPU crisis over. The team and I have been checking graphics card prices daily for many months, and at last it seems that sanity has returned to the market. You can now buy, as an example, an RTX 3080 in the \$1,200-range, while just a few months ago they were \$2,200 or more.

We hope this is the end of those bad old days, though to be realistic, while the crypto demand for GPUs has all but vanished, the supply and logistics issues that also contributed to insane pricing are still very much present.

So perhaps now is the time to buy. Prices are good and there's stock for most items just waiting to be added to your cart. Thus, now is also the time for APC to have a big old look at the state of play in the GPU scene to properly arm you with the knowledge you need as you consider a new card. In our cover story (page 56) we've created a hierarchy of GPUs you can buy today, and because many of you may indeed have been holding on to your older card longer than planned – how the last eight years of GPUs stack up.

We haven't looked at individual cards – just the GPUs. We're still seeing loads of fluctuation so we're not recommending particular models – but with our guide you'll know the GPU to shoot for and can jump on the best deal when it's time to buy.

The pretties to be had from a new GPU in gaming are a special thrill to be appreciated, but at the end of the process it's the monitor you run that is the ultimate presentation for your eager eyes. Screen tech is evolving so fast today and there's new display technologies hitting right now that can make a huge difference. OLED has just arrived, and micro-LED is just about to hit the market. We've put together everything you need

to know about what's here, what's imminent, and what's just around the corner. Head to page 50 to enjoy that one.

Whether you're a gamer or not, a new screen can be transformative, and because we tend to stick with the same monitor much longer than we keep other components before upgrading – the decision on what to buy is so important.

Lastly, we've given your mag a bit of a freshen up this month. It's not a major redesign and APC still feels like APC, but with the recent addition of all the cool new regular content in APC it felt right to have a bit of a play with the fonts and layout to give APC a nice new look to match.

Enjoy the month, see you next issue!

Editorial

Editor: **Ben Mansill** ben.mansill@futurenet.com

Senior Journalist: **Shaun Prescott**

Journalist: **Joel Burgess**

Journalist: **Chris Szewczyk**

Creative Director: **Troy Coleman**

Contributors

Alex Blake, George Cairns, Nat Clayton, Barry Collins, David Crookes, Tim Danton, Darien Graham-Smith, Robert Irvine, John Knight, Nicole Kobie, Jeremy Laird, Rick Lane, Christopher Livingston, Anne-Marie Ostler, Andrew Myrick, Nick Peers, Michael Reed, Sharmishta Sarkar, Mayank Sharma, Shashank Sharma, Tom Sykes, Chris Szewczyk, Jarred Walton, Mark Williams, Luke Winkie, Darren Yates

Photography

All copyrights and trademarks are recognised and respected

Advertising

auadvertising@futurenet.com

Management

Managing Director: **Neville Daniels**

Sales Director: **Paul Marttila** paul.marttila@futurenet.com

Printed in Australia by IVE

Distributed in Australia and NZ by Are Direct

ISSN 0725-4415

Future Publishing Australia

PO Box Q1179, Queen Victoria Building, NSW 1230

Corporate Web: www.futureplc.com

Email: apcmag@futurenet.com

Web: www.apcmag.com

We are committed to only using magazine paper which is derived from responsibly managed, certified forestry and chlorine-free manufacture. The paper in this magazine was sourced and produced from sustainable managed forests, conforming to strict environmental and socioeconomic standards. The manufacturing paper mill holds full FSC (Forest Stewardship Council) or PEFC certification and accreditation

All contents © 2018 Future Publishing Australia or published under licence. All rights reserved. No part of this magazine may be used, stored, transmitted or reproduced in any way without the prior written permission of the publisher. Future Publishing Limited (company number 2008885) is registered in England and Wales. Registered office: Quay House, The Ambury, Bath BA1 1UA. All information contained in this publication is for information only and is, as far as we are aware, correct at the time of going to press. Future cannot accept any responsibility for errors or inaccuracies in such information. You are advised to contact manufacturers and retailers directly with regard to the price of products/services referred to in this publication. Apps and websites mentioned in this publication are not under our control. We are not responsible for their contents or any other changes or updates to them. This magazine is fully independent and not affiliated in any way with the companies mentioned herein.

If you submit material to us, you warrant that you own the material and/or have the necessary rights/permissions to supply the material and you automatically grant Future and its licensees a licence to publish your submission in whole or in part in any/all issues and/or editions of publications, in any format published worldwide and on associated websites, social media channels and associated products. Any material you submit is sent at your own risk and, although every care is taken, neither Future nor its employees, agents, subcontractors or licensees shall be liable for loss or damage. We assume all unsolicited material is for publication unless otherwise stated, and reserve the right to edit, amend, adapt all submissions.

Privacy statement

If you provide information about yourself this will be used to provide you with products or services you have requested. We may supply your information to contractors to enable us to do this. Future Publishing Australia will also use your information to inform you of other publications, products, services and events. Future Publishing Australia may also give your information to organisations that are providing special prizes or offers and are clearly associated with the Reader Offer. Unless you tell us not to, Future Publishing Australia may give your information to other organisations that may use it to inform you of other products, services or events. If you would like to gain access to the information Future Publishing Australia holds about you, please contact us.



Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR)
www.futureplc.com

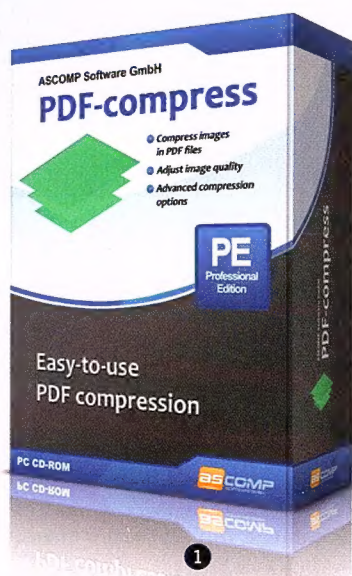
Chief executive **Zillah Byng-Thorne**
Non-executive chairman **Richard Huntingford**
Chief financial officer **Penny Laskin-Brand**

Tel +44 (0)225 442 244

FREEBIES

Exclusive downloads

Your free full-version apps as a thanks for reading APC. These exclusive downloads will only be available for a limited time, from 13/06/22 to 31/07/22.



1

ASCOMP PDF-COMPRESS

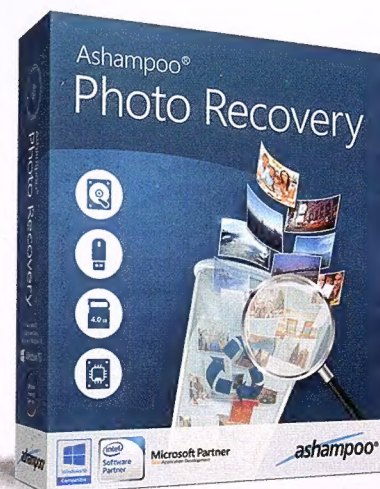
Provides PDF compression so you can optimise your PDF files so they don't take up much storage space.

Ascomp PDF-compress provides PDF compression so you can optimise your PDF files so that they don't take up more storage space than necessary. Depending on the structure and content of the PDF document, up to 95 percent compression can be achieved. In a test with more than 1,000 randomly selected PDF files from different sources, an average compression ratio of close to 50 percent was achieved.

Ascomp PDF-compress uses different approaches to compression. For example, images contained in a document can be lossless compressed, special optimisation technology (MRC) can be applied, and blank pages and annotations can be removed from the PDF structure. Optionally, image quality may also degrade in stages, and optimisation for web display may be performed.

- Easily compress PDF files to reduce size while keeping the original quality
- Support to compress PDF files in batch to save time
- Compatible with all current versions of Windows
- Easy to use

Download link: www.apcmag.com/exclusives



2

ASHAMPOO PHOTO RECOVERY

Recover accidentally deleted or corrupted image files.

Ashampoo Photo Recovery recovers deleted or corrupted image files. Either scan individual files for contained images or entire disk drives. You can even recover your photos from damaged RAW files or formatted disks. The latest version supports the recovery of embedded images from corrupted documents (e.g. PDF, Word, etc.) and various added RAW and image formats yield even better search results. New search filters help you better manage huge file amounts and allow you to precisely filter your results either by format, size or resolution.

- Recover deleted or corrupted image files
 - Scan all available drives
 - Recover photos from formatted disks
 - Recover metadata, e.g. EXIF or IPTC data
- Supports all common file formats such as JPG, PNG, BMP, GIF and RAW
- View photo results as thumbnails

Download link: www.apcmag.com/exclusives

DISCLAIMER Future Publishing is not the licensor of the exclusive software or any documentation included with it. Rather, Future is merely a distributor of the software, and your use of the software is subject to any accompanying third-party licence terms. You must carefully read and comply with any such third-party licence terms, together with all instructions and README files that come with the software. Accordingly, to the maximum extent permitted by law, all software is provided by Future 'as is' and without warranty either express or implied, and Future will not be liable for any damage that you may incur as a result of using any software downloads. You should back up any important system and data files before using any downloaded software. We recommend that you do not use the exclusive software on a production machine. Nothing in this disclaimer excludes any warranty that may be implied by statute, which may include the Trade Practices Act. While we have taken all reasonable steps to check the software downloads for viruses, we cannot guarantee that it is free from viruses or other harmful code and you should check each download using a virus scanner complete with the latest antivirus updates before use.

Performance to Rule Your Game

 **NITRO+**
PURE

SAPPHIRE PULSE
RX 6650 XT

SAPPHIRE TOXIC
RX 6950 XT

SAPPHIRE NITRO+ PURE
RX 6950 XT

SAPPHIRE NITRO+
RX 6950 XT

SAPPHIRE NITRO+
RX 6750 XT

AMD
RADEON
RX 6000 SERIES

SAPPHIRE

Available from a reseller near you.

Allneeds Computers Pty Ltd <https://allneeds.com.au/>
AMAZON <https://www.amazon.com.au/>
Arrow Computers <https://www.arrowcomputers.com.au/shop>
Crox Development <https://www.crox.com.au/>
First Blood <https://aufirstblood.com.au/>

MSY Technology <https://www.msy.com.au/>
MWAVE <https://www.mwave.com.au/>
PCBYTE <https://www.pcbyte.com.au/>
Scorpion Technology <https://www.scorpTec.com.au/>
Umart Online <https://www.umat.com.au/>

GRAPHICS CARD BUYER'S GUIDE

**BUDGET TO EXTREME &
EVERYTHING IN BETWEEN**



NVIDIA

VS

AMD

CAN INTEL'S ARC MAKE IT A 3-WAY CHOICE?

PLUS

- BEST LAPTOP INTEGRATED GRAPHICS
- RAY TRACING WITHOUT THE FPS HIT
- BEST GAME GRAPHICS SETTINGS
- WHAT YOU NEED FOR 4K

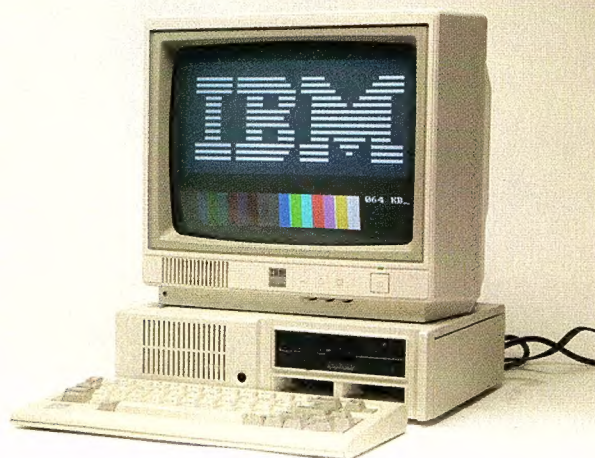
PAGE 56



SCREEN TECH IN 2022

OLED monitors are here at last. But as Jeremy Laird reveals, you can expect plenty more panel tech in 2022

050



THE WORLD'S MOST ICONIC PCs

The computers that changed perceptions of what computers could be, or inspired a new type of design

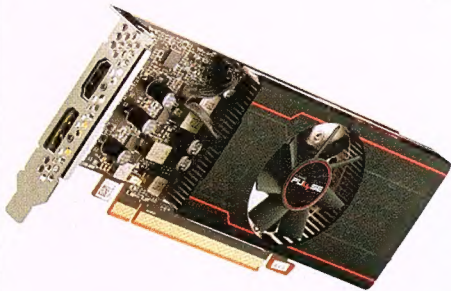
066



MSI CREATOR Z17

MSI's new creative professional Ultrabook has a 3070 Ti, but can it handle this kind of power?

036



SAPPHIRE PULSE RX 6400

040



LOGITECH LIFT VERTICAL MOUSE

044



SYNOLOGY RT6600AX

043



RAZER HUNTSMAN MINI ANALOG

045



MSI RADEON RX 6750 XT GAMING X TRIO

An overclocked 6700 XT?

039

TECHNOTES

- 10 **News**
What's happening in tech
- 12 **Tech brief**
Supermassive black hole image consumed 100 million CPU hours
- 15 **Computex news special**
All the big reveals from Computex 2022
- 17 **Two bits**
Let's look at AMD's Zen 4 CPUs and AM5 platform
- 18 **End user**
Videogame crossovers have reached a terrible fever pitch
- 19 **Tech talk**
AMD 3D V-Cache boosts gaming performance
- 20 **One more thing**
The unreliability of cloud computing
- 24 **Futures**
Crowdfunding Ukraine and the future of war
- 28 **A-list**
The best products on the market, as picked by our editors
- 31 **The list**
Best PC speakers
- 32 **Head to head**
OBS Studio vs XSplit Broadcaster
- 34 **Gadgets**
Techy toys and trinkets

THE LAB

- 36 MSI Creator Z17
- 37 MSI Crosshair 15
- 38 MSI Radeon 6750 XT Gaming X Trio 12G
- 39 MSI Radeon RX 6650 XT Gaming X 8G
- 40 Sapphire Pulse RX 6400
- 41 DeepCool LS720 (360mm) AIO
- 42 TP Link Deco X73-DSL
- 43 Synology RT6600ax
- 44 Logitech Lift vertical mouse & G.Skill Trident Z5 DDR5-5600 CL28
- 45 Razer Huntsman Mini Analog

SOFTWARE

- 46 Windows
- 47 Apple Mac
- 48 Android apps
- 49 Linux

FEATURES

- 50 **Screen tech in 2022**
OLED monitors are here at last, and you can expect plenty more panel tech in 2022
- 56 **GPU Buyer's Guide**
Eight years of graphics cards put to the test

- 66 **The world's most iconic PCs**
The computers that changed perceptions of what computers could be, or inspired a new type of design

PC BUILDER

- 74 **System news**
Mark Williams puts on his 3D glasses to bask in a new era of chip design
- 75 **Market watch**
A sampling of PC systems available
- 76 **Blueprints**
Value- and performance-driven hypothetical builds

HOW TO

- 80 **Quick tips**
Solving a variety of tech problems
- 82 **Advanced Windows 11 tips:** Registry editor
- 86 **How to tame Windows Update**
- 90 **Manage macOS notifications**
- 92 **The supercharged file manager**

MASTERCLASSES

- 94 **Using the Pi as a daily driver**
- 98 **Tech that changed Australia (and the world) Part 2**

DOWNTIME

- 100 **Machine of the month**
NEC PC-9800 (1982)
- 102 **Gaming reviews**
High-performance playtime
- 106 **Game changer**
Supreme Commander
- 110 **Retro**
Amstrad Notepad NC100
- 114 **Chip chat**
The less than serious news page



SUBSCRIBE NOW!

Turn to page 22 now to find out how

HOW WE DO IT

Inside APC

Find out all about APC's editorial policies, test practices, how to read the benchmark results, and more.



"Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage."

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, APC's journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in APC are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in APC, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

apc TESTBED

The current APC testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	Zotac RTX 3080 Ti AMP Extreme Holo
Memory	Crucial Ballistix Sport DDR4-3600 2x16GB
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

apc AWARDS



APC EDITOR'S CHOICE

When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.



APC HIGHLY RECOMMENDED

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

BILLION

5GHz
1733Mbps

2.4GHz
600Mbps



CAT.6

BiPAC 4520VAOZ R3

 First International
Trading Pty Ltd.

4G/LTE Dual-SIM Dual-Band Wireless VoIP VPN Router



**Enables high-speed and secured Internet connectivity
for home, SOHO, and enterprise users.**

- ▶ 4G LTE Mobility
- ▶ Dual Radio/Dual SIMs
- ▶ 4X4(1733Mbps at 5GHz)/3x3(600Mbps at 2.4GHz)
- ▶ Automatic Failover/Failback
between 4G/LTE and Gigabit EWAN



au.billion.com



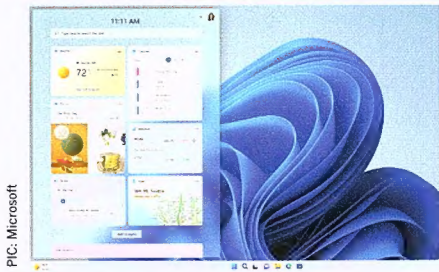
(02) 8318 3777



sales@firstint.com.au



Unit 5, 1 Talavera Road, Macquarie Park NSW 2113



PIU: Microsoft

MICROSOFT TO WELCOME
THIRD PARTY WIDGETS IN
WINDOWS 11

*What third party widgets
would you like to see?*

Microsoft announced that third party widgets will be enabled in Windows 11 beginning “later this year.” Widgets are a handy way to present bite-sized bits of information without hogging screen real estate. They’re easy to summon and dismiss, letting you quickly check some news or other real-time information and get back to your main task(s).

At present, Microsoft is the sole provider and publisher of Windows 11 widgets. This obviously limits the scope of the offerings, but there are still some useful widgets designed to show snippets of news, to do lists, weather, traffic, your Outlook calendar, and stock prices. However, most if not all of the existing widgets won’t work if you use a local account to sign into Windows 11, rather than a Microsoft account.

AMD GAINS CPU SHARE
AMID BIGGEST QUARTERLY
DECLINE IN HISTORY

Riding the crashing wave.

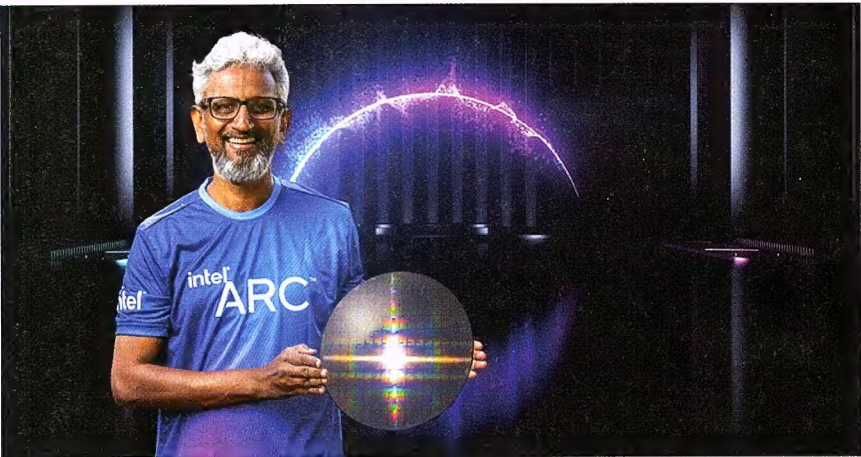
The Mercury Research CPU market share results are in for the first quarter of 2022, and the results are somewhat dire – Dean McCarron from Mercury reports that aside from IoT/SoC, all segments of the x86 processor market declined during the quarter. Desktop PCs suffered the most as units declined by 30 percent, the largest quarterly drop in history. That’s an incredible reversal after two years of component shortages that kept many PC builders on the sidelines.

Surprisingly, AMD managed to carve out significant wins during the tumultuous quarter and has now, once again, set a new record high x86 market share of 27.7 percent, an incredible increase of seven percentage points over last year.

HARDWARE

Intel Arc desktop
GPUs likely delayed

The hardware might be ready, but the rumour is that the software isn’t.



The release of Intel’s Arc Alchemist desktop graphics cards could be postponed, according to a new report published by Igor Wallossek on his Igor’s Lab tech site. Multiple sources have contacted Wallossek, and all agree that these desktop GPUs will be late, but how late isn’t clearly defined, with the release window now expected to fall between the beginning of July to the end of August.

Intel’s official position concerning the release of its Arc Alchemist desktop graphics cards is that they will start to roll out in Q2 2022. However, we are now firmly into Q2, and Q3 begins at the beginning of July. So a hard launch at the beginning of July would be a little late, but the end of August is quite a severe delay.

In May Intel missed its self-imposed deadline to deliver an Arc GPU driver update. It could be a symptom of the hardware release delays to come. In the body of his news post, Wallossek seems to indicate that some of his sources are “preferred testers.” Suppose the wider tech community has noticed a delay in Intel’s software update delivery schedule. In that

case, the professional testing community will be highly frustrated about such delays, which may have something to do with this report.

Intel has many hoops to jump through with its first serious series of discrete graphics cards. So it is natural to wonder whether the delayed cards will have all their advanced features available, like XeSS, when they eventually launch. Remember, AMD seemed to stumble over the introduction of FSR, but now it has that feature in the rear view mirror; it has been able to successfully tune and refine this feature (and FSR2) alongside others in its updates.

Igor shares some other interesting observations about the Arc Alchemist desktop launch delay. He indicates that Intel’s delay or leaked specs of the upcoming hardware may have helped Nvidia decide to cancel the GeForce RTX 3070 Ti 16GB. He also reckons the Intel Arc Alchemist desktop graphics card launch may be a muted one due to the absence of big board partners, lack of retailer price guarantees, and RMA considerations.



PIU: Intel

Biden administration doubles down on quantum computing strategy

Aiming to ensure quantum advantage and resilience.

The U.S. is looking to accelerate its quantum computing and post-quantum security push as it works to remain resilient in the face of the breakneck speed of research in the field. President Joe Biden signed two directives in May relating to the quantum push – an Executive Order creating the National Quantum Initiative Advisory Committee, as well as a memorandum. Both aim to outline the U.S. priorities in quantum computing leadership and the hardening of its information systems against quantum-based attacks on its sovereignty.

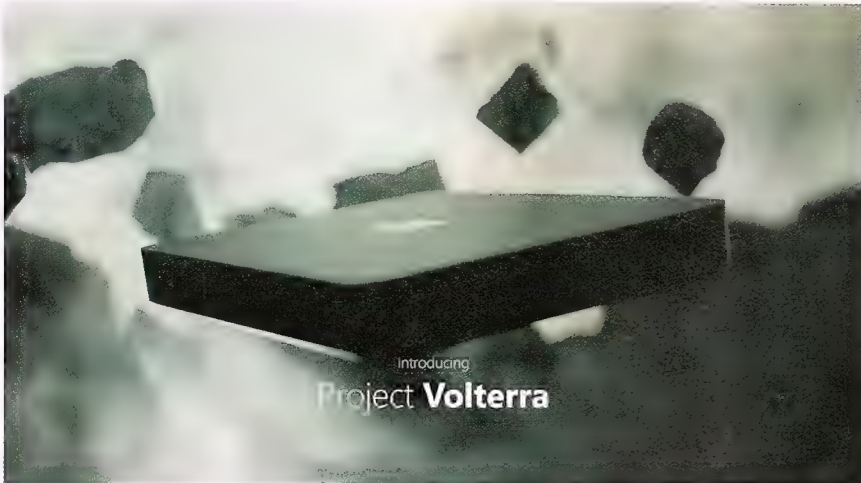
The now instated National Quantum Initiative Advisory Committee will operate under the authority of the White

House and is comprised of up to 26 president-appointed experts hailing from industry, academia, and federal laboratories.

"Attributed to the US Department of Commerce and the National Institute of Standards and Technology (NIST), the effort is a monumental one"

The memorandum, on the other hand, focuses on taking stock of currently deployed cryptographic algorithms in preparation for the country's federal and state-level IT infrastructure integration of quantum-resistant cryptography. Attributed to the US Department of

Commerce and the National Institute of Standards and Technology (NIST), the effort is a monumental one: implementing post-quantum cryptography will undoubtedly present issues in terms of infrastructure.



MICROSOFT ANNOUNCES WINDOWS 11 ON ARM DEVELOPER KIT

Microsoft's first 'desktop' PC arrives in the form of an ARM devkit.

Microsoft has announced new hardware at Build 2022! Given that Build is a developer conference, it should come as no surprise to hear that the hardware being announced today is a developer kit designed to help devs to build apps that take advantage of new AI capabilities via an onboard neural processing unit (NPU), as well as add support for Windows 11 on ARM.

The developer kit is called "Project Volterra," and is powered by an as-yet-unnamed Snapdragon processor. The device is a mini-desktop PC, similar in shape and size to that of a Mac mini or the base of a Surface Studio, just without the display attached. This developer kit is also Microsoft's first 'desktop' PC, though it doesn't plan to sell the device as a consumer product.

NVIDIA OPEN-SOURCES LINUX DRIVERS

Data centre focus, with GeForce and Workstation "alpha quality" support.

Nvidia has announced that it will be open-sourcing the Linux drivers for its graphics cards, starting with the R515 release, using a dual GPL/MIT license. The source code for the kernel modules will be available in the Nvidia Open GPU Kernel Modules repo on GitHub, but at the moment only the code for data centre GPUs is considered production-ready. GeForce and Workstation GPUs are considered "alpha quality" at this time.

With fully built packages available, as well as the source code, the move will make it easier for distro managers to include the drivers in their software repositories, with both Canonical (makers of Ubuntu) and SUSE named as developers who can now package the open kernel modules with their distros.



PIC: Microsoft

FLY LIKE A SKILFUL MANIAC IN FLIGHT SIM'S TOP GUN TIE-IN

Escape the chains of airspace common sense.

With a new *Top Gun: Maverick* expansion released in late May, we're now invited to perform ridiculous, high-skill manoeuvres in a specially decked-out F/A-18E Super Hornet, thus eliminating every trace of "chill" this game normally offers.

The free update is a promotion of sorts, but there's no Tom Cruise skin. Instead, it adds a bunch of missions and challenges. The three new training missions teach players how to pull off "radical flight manoeuvres". There's a carrier deck landing challenge, and most excitingly, "a never-before-unveiled hypersonic aircraft that can attain speeds of Mach 10 and altitudes greater than 150,000 feet above sea level." Elsewhere, there's a mission to reach the stratosphere, as well as five "high-speed, low-level" challenges. Heck! ■

TECH BRIEF

Supermassive black hole image consumed 100 million CPU hours

The equivalent to 11,415 years of compute.

"Frontera leverages 448,448 CPU cores courtesy of 16,016 units of Intel's Xeon Platinum 8280 chips, a Broadwell-class CPU leveraging 28 Intel cores."

The image released in May showcasing the supermassive black hole in the centre of our galaxy, the Milky Way, owes its existence to human ingenuity – and to our old friend, the CPU. Achieved thanks to a five-year partnership and research between the Event Horizon Telescope (EHT) array, the Frontera supercomputer at the Texas Advanced Computing Center (TACC) and NSF's Open Science Grid.

The galactic-level task took around 100 million CPU hours and the concerted efforts of 300-plus researchers to coalesce into the released image. But how does one "see" a black hole that's so massive its gravitic forces trap even near-lightspeed

moving particles? Well, one can actually see the contours of the black hole by paying attention to the comparably minute amount of light that actually manages to escape its event horizon. To create it, the researchers made use of the interferometry, radio wave-based scanning power of the EHT array, which includes eight radio telescopes deployed around the globe.

To that effort, the researchers created a simulation library of black holes that leveraged the known physical properties of black holes, general relativity, and a number of other scientific areas. The idea was that this library could parse the enormous amount of data captured by the EHT array into an actual, viewable image – but to do so, an enormous amount of power and computing was not only necessary – it was mandatory.

"We produced a multitude of simulations and compared them to the data. The upshot is that we

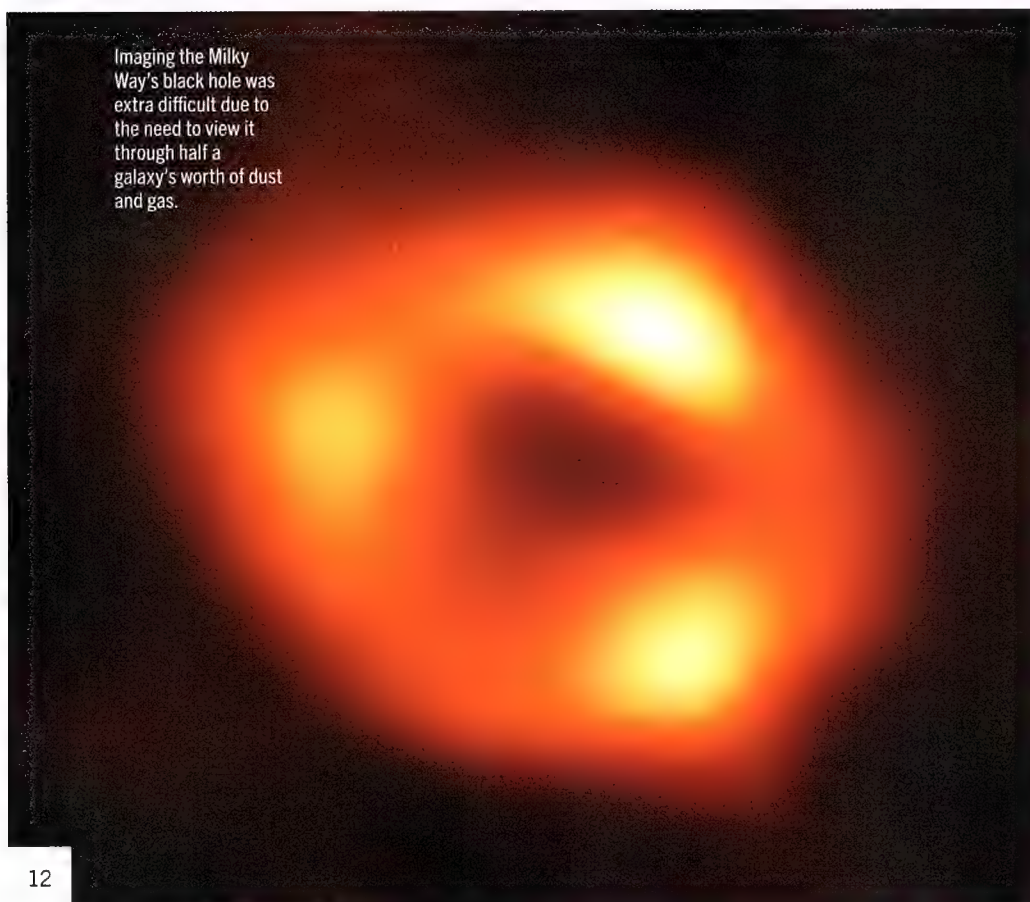
have a set of models that explain almost all of the data," said Charles Gammie, a researcher at the University of Illinois at Urbana-Champaign. "It's remarkable because it explains not only the Event Horizon data, but data taken by other instruments. It's a triumph of computational physics."

The vast majority of the required computing hours – around 80 million – were run on TACC's Frontera system, a 23.5 petaflops, CentOS Linux 7-based Dell system currently ranking 13th on supercomputing's Top500 list. Frontera leverages 448,448 CPU cores courtesy of 16,016 units of Intel's Xeon Platinum 8280 chips, a Broadwell-class CPU leveraging 28 Intel cores running at 2.7GHz. The remainder 20 million simulation hours were computed on the NSF's open Science Grid, which leverages unused CPU cycles in a distributed computing fashion to unlock compute capabilities without the need to deploy costly supercomputers and related infrastructure.

"We were stunned by how well the size of the ring agreed with predictions from Einstein's Theory of General Relativity," added Geoffrey Bower, an EHT project scientist with the Institute of Astronomy and Astrophysics of Taipei. "These unprecedented observations have greatly improved our understanding of what happens at the very centre of our galaxy and offer new insights on how these giant black holes interact with their surroundings."

The researchers' efforts are sure to redouble after the endeavour's success, and they're now planning on doing something even more extraordinary: rather than a single still image, the next step is to film the black hole throughout a period of time, capturing the dance of the simultaneously wave and particle-like photons to showcase the black hole's dynamics. One can only wonder how many millions of CPU hours that effort will take. ■

Imaging the Milky Way's black hole was extra difficult due to the need to view it through half a galaxy's worth of dust and gas.





SAMSUNG'S BEST 4K TV EVER! OUR FULL REVIEW

AUSTRALIAN

T3

SMARTER LIVING

Winter 2022 // \$9.95

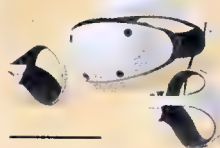
BEST TECH FOR EVERYTHING

Stunning OLED TVs • Best garden gadgets
Handy travel tech • Next-gen gaming gear

PS VR2

COMPLETE GUIDE

Gamechanging – just like the PlayStation 5!



REVIEWED

iPAD AIR GOES PRO



iPHONE SE

Affordable, fast and built to last



SAMSUNG'S 14-INCH TABLET

Why it's the future of computing



THE HOTTEST HOME UPGRADES

Give your pad a refresh



TOP GADGETS
FOR WHEN YOU'RE ON THE MOVE

STEAM DECK

Gaming will never be the same



9 771445 290004
10
AUS \$9.95 INC GST
NZ \$10.95 INC GST
PRINT POST APPROVED
100007719 ISSN 1445-2904

Onsale Now

www.t3.com/au



FEATURE

Computex 2022

The biggest reveals from the most important PC show in the world.

Computex 2022 ran from May 23 - May 27 in Taipei, Taiwan, and it's the biggest and most exciting computing event in the calendar. Unlike last year, which was online-only (with Computex 2020 being cancelled altogether), Computex 2022 happened in-person.

But because Taiwan is still limiting international visitors due to the Covid-19 pandemic, press from other parts of the world weren't there in the kind of numbers we've been used to seeing pre-pandemic. And that includes us. APC has remotely

covered Computex 2022 via a full week of virtual press briefings and announcements. Here's all the biggest breaking news from the show.

There were keynote presentations from Nvidia and AMD, as well as showings from Asus, Gigabyte and more. A great many of these big players all have headquarters in Taiwan, of course; other international companies may not be present. That's the case for Intel, which is probably the most noticeable absence from this year's event.

AMD INTRODUCES ZEN 4 RYZEN 7000 CPUs AND AM5 MOTHERBOARDS

AMD CEO Lisa Su revealed more details about the upcoming Ryzen 7000 series processors and the 600-series motherboards, both of which will arrive in Q3 2022. The company demoed a 16-core Ryzen 7000 processor hitting an amazing 5.5 GHz during a gaming demo, and also completing a Blender render in 31 percent less time than Intel's flagship Core i9-12900K. As expected, we also learned plenty of new details about the 5nm Zen 4 Ryzen 7000 'Raphael' processors and the new wave of motherboards with the AM5 socket.

AMD claims the Ryzen 7000 processors will have >15 percent more single-threaded performance than their Zen 3 predecessors

(not IPC), up to a 5GHz+ maximum boost frequency, come with integrated RDNA 2 graphics (a first), and will support only DDR5 memory. In addition, the chips have 5nm CPU chiplets for the cores, a 6nm I/O die, and twice the L2 cache (1MB) per core.

The Ryzen 7000 processors come with expanded instructions for AI acceleration, but AMD isn't sharing details yet. AMD has also doubled the L2 cache per core to 1MB for Zen 4, giving the execution cores a hefty slab of near memory for workloads.

AMD splits the 600-series chipsets into a new X670E (Extreme) upper-tier in addition to the standard X670 and

"We also learned plenty of new details about the 5nm Zen 4 Ryzen 7000 'Raphael' processors"

THE NEXT FRONTIER OF RYZEN™ MOTHERBOARDS

Socket AM5 Infrastructure

- 1718 pin LGA socket
- Native support for up to 170W
- DDR5 and PCIe® 5.0 Support
- Compatible with Socket AM4 coolers

WORLD'S FIRST 5nm PC PROCESSOR CORES

Zen 4 CPU core chiplets in 5nm

All-new I/O Die in 6nm

Integrated AMD RDNA™ 2 graphics

Advanced low-power architecture

DDR5 and PCIe® 5.0 controllers

Above: AMD's switch to next-gen AM5 boards introduces several compelling features – including a max power limit of 170 watts.

Top: The new 5nm process allowed AMD to add integrated graphics as standard.

B650 swim lanes. The X670E motherboard will come with full support for PCIe 5.0, while the X670 and B650 will have varying levels of support for PCIe 5.0 or 4.0 (details below). AMD also revealed that the AM5 socket would support up to 170W of peak power, which will be helpful for high core-count models. The RDNA 2 engine also supports up to four display outputs, including HDMI 2.1 and DisplayPort 2 interfaces.

AMD 600-Series chipset with AM5 Socket: X670E Extreme, X670, and B650 motherboards

AMD's socket AM4 has soldiered on for five years across five CPU generations, four architectures, four process nodes, 125+ processors, and 500+ motherboard designs, so it's time for a new refreshed series of motherboards.

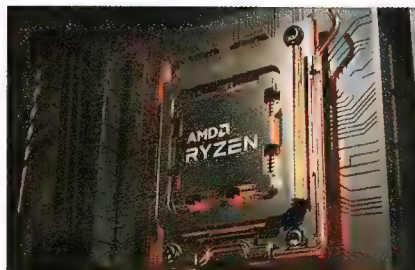
The Raphael processors will drop into a new AM5 socket that supports both the PCIe 5.0 and DDR5 interfaces, matching





Below: While we were hoping for news about the RTX 4000 series, none came, but the AI and server reveals showed how serious the company is about this area.

Bottom: Nvidia's Grace-Hopper represents the company's push into the server market.



Above: Ryzen 7000 has a rather attractive new shape. Pity it'll be covered up...

Top: Partner support for AM5 boards is strong right out of the gate.

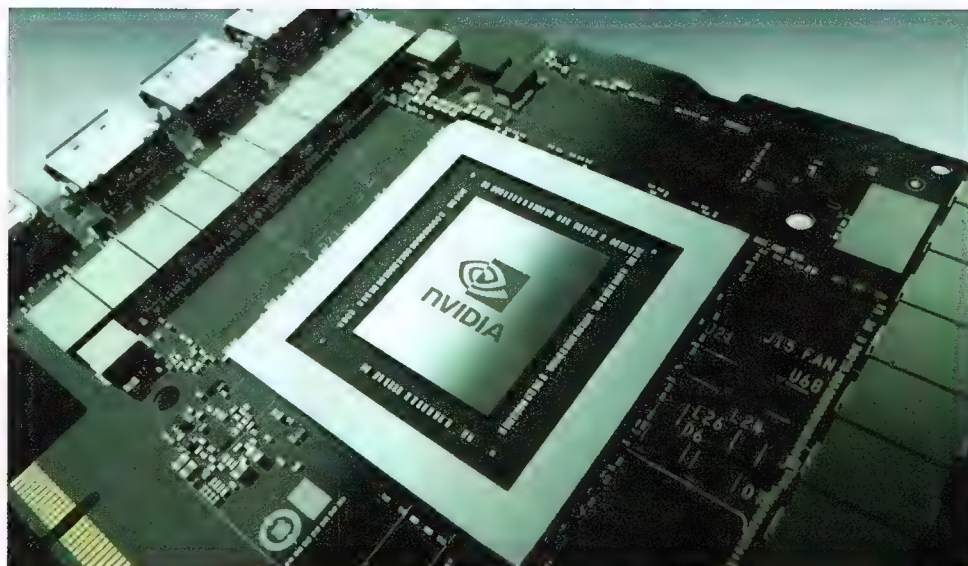
Alder Lake on the connectivity front. This new socket marks a big departure for AMD – the company is moving from its long-lived Pin Grid Array (PGA) AM4 sockets to a Land Grid Array (LGA) AM5 layout. Despite the entirely different LGA1718 socket interface (1,718 pins), the AM5 socket will still support AM4 coolers.

The Socket AM5 motherboards will offer up to 24 lanes of PCIe 5.0, the most PCIe 5.0 lanes direct from the socket in the industry. The chipset also supports up to 14 SuperSpeed USB ports up to 20Gbps and Type-C, along with support for Wi-Fi 6E with DBS and Bluetooth LE 5.2. AMD hasn't specified, but the Wi-Fi 6E support comes as a discrete chip from the company's initiative with MediaTek.

The X670E 'Extreme' chipset will support PCIe 5.0 for two graphics slots and one M.2 NVMe SSD port. This chipset is designed for motherboards that aim for extreme overclockability, carving out a new tier above AMD's standard lineup.

The X670 chipset powers the 'standard' high end motherboards and will come in multiple flavors with varying PCIe support. The M.2 port will support the PCIe 5.0 interface, but the first graphics slot can support either a peak of PCIe 4.0 or PCIe 5.0, which will vary by the motherboard. This offers a lower-cost sub-tier of PCIe 4.0 X670 motherboards.

The B650 chipset will support PCIe 5.0 for a single NVMe port, but only PCIe 4.0 for the graphics slot. This chipset also supports overclocking, but as per usual, you won't find as robust of power accommodations as you will with the more expensive boards.



NVIDIA'S MONSTER 144-CORE GRACE CPU SUPERCHIP IS COMING TO A SYSTEM NEAR YOU

PC gamers might be left feeling a tad deflated, as we were hoping Team Green might tease its RTX 4000 series of 'Lovelace' GPUs that are speculated to be released later this year. Sadly, these didn't make an appearance, but there's still a good chance we will be fed some scraps of information from Nvidia ahead of the RTX 4080 and RTX 4090 unveiling, rumoured to be as early as July.

What we did get however was a lot of new data centre and advanced computing announcements, with designs teased for the Grace-Hopper superchip that's set to ship in early 2023. Nvidia has revealed that its highly-anticipated Grace CPU Superchip is set to feature in a range of new servers launching in the first half of 2023.

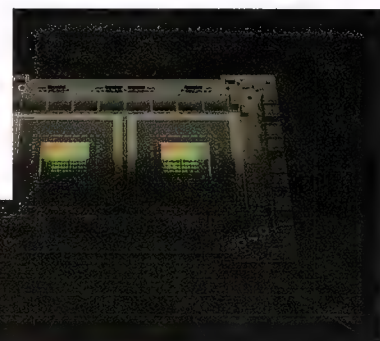
The new systems – from the likes of Asus, Gigabyte, Supermicro and others – will be based on four new 2U reference designs teased by Nvidia at Computex 2022. The Grace CPU Superchip is comprised of two Grace CPUs linked up

via high-speed NVLink interconnect, in a similar fashion to Apple's M1 Ultra chip, and offers a huge 144-cores with 1TB/s of bandwidth.

While PC gamers didn't get any new GPUs from Nvidia at Computex 2022, professional users had a lot to enjoy, including new liquid-cooled GPUs, the first time the company has offered direct-to-chip liquid cooling. They won't be for gaming, but come with A100 GPUs which include a HGX A100 server, and are designed for data

centres, and should allow these centres to keep cool more efficiently.

"PC gamers didn't get any new GPUs from Nvidia at Computex 2022"





CORSAIR'S FIRST GAMING LAPTOP IS POWERFUL AND THIN

One of the biggest surprises of Computex 2022 came during AMD's keynote, where it was announced that component maker Corsair was going to launch its first ever gaming laptop.

Corsair is a well-known brand in PC gaming, but it usually makes components and peripherals, rather than systems. However, in recent years its Corsair One compact gaming PCs have been gaining a lot of attention, and now it'll also make laptops with the Corsair Voyager.

As you may expect by it being announced during AMD's keynote, the Corsair Voyager a1600 AMD Advantage Edition features Ryzen 6000 mobile CPUs in combination with Radeon RX 6800M graphics, plus bags of RAM and storage. We always like seeing new companies join the laptop market, so we'll be keeping a close eye on this one.

MICROSOFT USES COMPUTEX 2022 TO SHOW HOW WINDOWS 11 CAN FIT INTO OUR LIVES

Microsoft used its presentation to talk about how Windows 11 can fit into people's lives. In a video played at the event, Panos Panay, Chief Product Officer for Windows and Devices at Microsoft, and Nicole Dezen, VP of Device Partner Sales, explained that going by Microsoft's data, people are accepting the offer to upgrade to Windows 11 at twice the rate that was witnessed with Windows 10, with businesses apparently adopting the new OS faster than with any previous versions of Windows.

INTEL AT COMPUTEX 2022

Sadly, Intel wasn't at this year's event. This is likely to be because of Taiwan's still strict Covid-19 policies. Unlike Nvidia and AMD, which are based in Taiwan, Intel executives may have found it too complicated to attend in any meaningful capacity.

Instead, Intel held its own event earlier this year, where we found out more about the upcoming Raptor Lake processors and Arc Alchemist GPUs – which will see Intel take on AMD and Nvidia in the gaming graphics card market.



Let's just pause to remember that gaming on a CRT monitor in the old days had zero input lag. That's what this seemingly insane LCD refresh rate push is trying to get back to.

"This is very much a display for people who exclusively play competitive esports titles."

IS THERE ACTUALLY ANY POINT IN A 500HZ GAMING MONITOR?

Nvidia didn't release any new graphics cards during its keynote, but it did introduce its latest collaborative effort with Asus to create the world's fastest gaming monitor: the Asus ROG Swift 500 Hz.

But will anyone actually get the full benefit of that refresh rate, given the human eye can supposedly only see 60 FPS? Introduced as the "lowest latency, highest refresh rate G-sync esports display ever created" in the

announcement, the Asus Rog Swift 500Hz has a 1080p resolution 24-inch screen with a brand new TN panel.

This is very much a display for people who exclusively play competitive esports titles. TN panels are very low latency but use dated technology by modern display standards as a tradeoff; you're sacrificing display quality for speed. That said, the market is hardly lacking in options for those of you who want something with both a high refresh rate and resolution.

MEDIATEK'S WI-FI 7 PROMISES SPEEDS 100X FASTER THAN YOUR AVERAGE BROADBAND

One of the best things about Computex is getting an idea of what the future of tech will be like, and Mediatek did just that by talking about its Wi-Fi 7 chips that could offer incredible speeds, and over 100 times faster than your average broadband speeds. Could this be the end of Ethernet?

Mediatek announced that it will ship its first Wi-Fi 7 platform, with one chip for clients (i.e. smartphones, tablets, computers etc) and another one for the access point (be it a WAP or a router for example). Mediatek is at loggerhead with

arch rival Qualcomm, which showed off its FastConnect 7800 Wi-Fi 7 connectivity chip at Mobile World Congress 2022. ■



PIC: Corsair, Asus, Mediatek

END USER

Videogame crossovers have reached a terrible fever pitch

Fun at times, crossovers also destroy the worlds of the game's they feature in, writes Shaun Prescott.



Something that feels distinctly 21st century is the way all mass market entertainment feels like it belongs to the same world. As a child of the 1990s, the prospect of say, *Star Wars*, DC Comics, and the Wu-Tang Clan all inhabiting the same cultural universe would have seemed ridiculous, and also, I guess, pretty damn cool. But here we are in 2022, and the shrinking of the boundaries between many and all imaginary worlds is starting to have a disillusioning effect.

If you vigilantly avoid the world of videogames it may come as a surprise that *Star Wars*, DC Comics and the Wu-Tang Clan have, in fact, shared the same universe, and that universe is *Fortnite*. Epic Games' unfathomably popular free-to-play battle royale ostensibly has its own lore, but aside from the core gameplay itself, it's really just a platform for various lucrative cross-promotions with other huge entertainment brands. It makes a bit of sense when it comes to *Fortnite*. With its vigilantly generic cartoon art style and (perhaps deliberate) lack of its own compelling storytelling, *Fortnite*'s porous, spongy inheritance of any pop culture phenomena is basically its identity. But this being videogames,

other developers and publishers have taken note, and the *Fortnite*-ification of other popular titles is now happening in earnest.

Cross-promotions like this are hardly new, of course, but they're punishingly ubiquitous in 2022. *Rainbow Six Siege*, a serious, competitive 5v5 tactical shooter with a huge amount of roleplay potential and its own decently fleshed out world, has lately started welcoming bizarrely incongruent characters from other media, including *Rick & Morty* and *Yakuza*. If, like me, you're the kind of player who enjoys being transported to another world by games, the appearance of a neon-hued Morty during a high-tension hostage rescue mission in a suburban home... might just be a bit disenchanting. And it's not just me, a curmudgeon, who doesn't like this: when the *Rick & Morty* crossover was announced the *Siege* reddit was swamped with complaints. It seems to point to a rapidly diminishing sense of imagination not just in games, but in popular culture as a whole, which relentlessly mines its own past in order to gratify an incredibly easy-to-provoke sense of nostalgia. And while these lucrative crossovers undoubtedly please droves of players, it persistently

undermines the efforts of developers who may want to create their own, completely new, universe. It also creates the morbid sense that our collective imagination is pretty much dead, and that popular culture nowadays is just a kind of compilation, or montage episode, celebrating past achievements before the season ends.

What if, when someone is playing *Rocket League*, they want to imagine they're in a ridiculous futuristic world where hotted up cars play vehicular soccer? A world, mind you, where James Bond doesn't exist? Impossible, because there's a James Bond car in it now. What if I play *PUBG* to inhabit a high-stakes world of dog-eat-dog realistic gunplay? I have to hope that someone on my server hasn't bought the *Neon Genesis Evangelion* skins.

There are holdouts: Blizzard, for all its recent faults, seems reluctant to contaminate *Overwatch*'s world with other media, and of course the singleplayer world isn't quite so awash in cross-promotions.

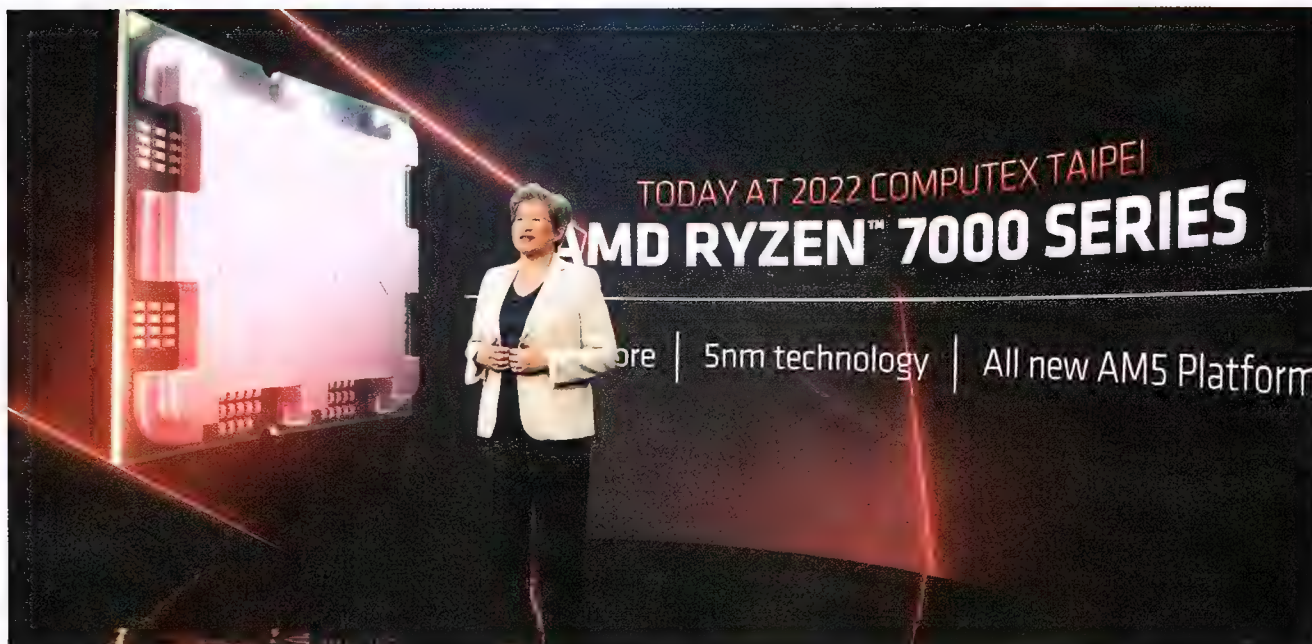
But if things keep developing in this direction for multiplayer games, it'll be hard to enjoy your transportative leisure time without feeling like you're being relentlessly marketed to. ■

A blurring of cultural borders has infected *Fortnite* and other games.

TWO BITS

Let's look at AMD's Zen 4 CPUs and AM5 platform

What can we expect from AMD's challengers?



Computex made a return in 2022. Though it wasn't on a pre-pandemic scale, it still provided an opportunity for companies to show off some of their upcoming tech, much of which you can read about in our Computex special on the previous pages. From a PC perspective, the biggest reveals

were from AMD. What can we expect from Ryzen 7000 CPUs and AM5 motherboards when they launch later in 2022?

Firstly, is it just me or do the heat spreaders of Ryzen 7000 processors look seriously cool? I

hope they're functional and that thermal goo isn't easily trapped under the edges. On top of general architectural improvements, Zen 4 features higher clocks, a doubling of L2 cache and 1:1 Infinity Fabric, which for DDR5-4800 means 2400MHz+ and hopefully a lot more.

The increase in power consumption is interesting. A 125W

TDP with a 170W upper limit is an increase of 20W and 28W respectively. This would indicate that AMD can maintain its performance per watt lead over Intel. If a 12900K has a 241W PL2 limit, how high will a 13900K go? If it can convincingly beat a 7900X or 7950X then it won't matter, but I hope that Intel doesn't resort to a brute force approach to beat AMD, especially in the all-important marketing dot point of having the fastest gaming CPU. Winning by five percent at 720p with double the power consumption is a win, but not a very attractive one. Of course, that's just the high-end models. The likes of a 13700K vs a 7800X or 13400 vs 7600X are battles we're also looking forward to covering.

For now, there's no mention of stacked V-cache models. Is AMD saving that for a mid-life refresh? 13th Gen Raptor Lake is expected to be an evolution of 12th Gen Alder Lake. It's expected to have more E cores, higher clocks and larger caches which might mean Intel is more than competitive with Zen 4, even before Meteor Lake arrives. Given that the 5800X3D is able to at least match a 12900KS in gaming, despite its lower clock vs a 5800X, a 7800X3D would seem to be almost a

certainty at some point, perhaps in early 2023.

AMD has shown how capable it is when designing multi-chip products. X670E and X670 motherboards include dual chipsets, while B650 has just one. The ability to daisy chain gives AMD flexibility to cater for different markets with different amounts of connectivity without having to design several different chips. Dual chips should have lower cooling demands and improved signal integrity. This kind of design might be the way of the future.

The AM5 platform is set to remain relevant for many years to come. An investment in a good quality X670 or B650 board is likely to last you for several years. Might you be able to drop a Zen 6 or 7 CPU and DDR5-10000 into one in a few years' time? The inclusion of a 32MB BIOS ROM would indicate so. Add to that PCIe 5.0, RDNA 2 integrated graphics and compatibility with existing AM4 coolers and AMD well set for the years to come, but only if its CPU performance is competitive.

Zen 4 and AM5 are scheduled to launch in our springtime, so the launch is closing in, but it's not yet imminent. You can be sure we'll be all over the platform when the time comes. ■

"I hope that Intel doesn't resort to a brute force approach to beat AMD, especially in the all-important marketing dot point of having the fastest gaming CPU."

The icing on top

AMD 3D V-Cache boosts gaming performance.

We've known for ages that large caches can help improve performance, though larger caches can also increase latency and counteract those gains. It's a balancing act, and L1 caches have been sitting in the 32KB to 96KB range for quite some time now.

L2 caches have grown from around 128KB per core in the 90s to today's 512KB to 1MB, sometimes even 2MB, per core. But it's the L3 cache sizes that have really ballooned. Intel's various mainstream Core processors have included 8MB of L3 cache going back to the Bloomfield and Lynnfield chips in the late 2000s. In contrast, AMD chose to put 16MB of L3 cache (per eight cores) on its first- and second-generation Ryzen processors, then doubled that to 32MB of L3 (still per eight cores) on the third- and fourth-generation CPUs, Zen 2 and Zen 3. One big difference between them was that Zen 3 made it a unified L3 cache, instead of a split 16MB+16MB cache, which reduced latencies and improved performance. But AMD had bigger plans.

From the start, Zen 3's Core Complex Die (CCD) has had Through Silicon Vias (TSVs) that

were intended to link up with a larger stacked cache. It was likely intended for the data centre Epyc chips, but AMD has also released a consumer Ryzen 7 5800X3D with 64MB of stacked 3D V-Cache. AMD is becoming the cache company, using large caches to boost performance. The current RDNA 2 graphics architecture took the previous design and added up to 128MB Infinity Cache, which alleviated a lot of GDDR6 memory traffic and allowed a boost in performance without needing much more memory bandwidth – unlike Nvidia's use of GDDR6X.

The cache chiplet sits atop the existing L3 cache structures of the Zen 3 CCD, with a silicon shim above the hotter running CPU cores. Stacking a large cache on top of an existing design involves tradeoffs. The 5800X3D has lower base and boost clocks than the 5800X, and the extra layer of silicon on the main die reduces the ability to dissipate heat. AMD has disabled overclocking on the 5800X3D as a result, and the CPU cores get hotter while using less power and running lower clocks.

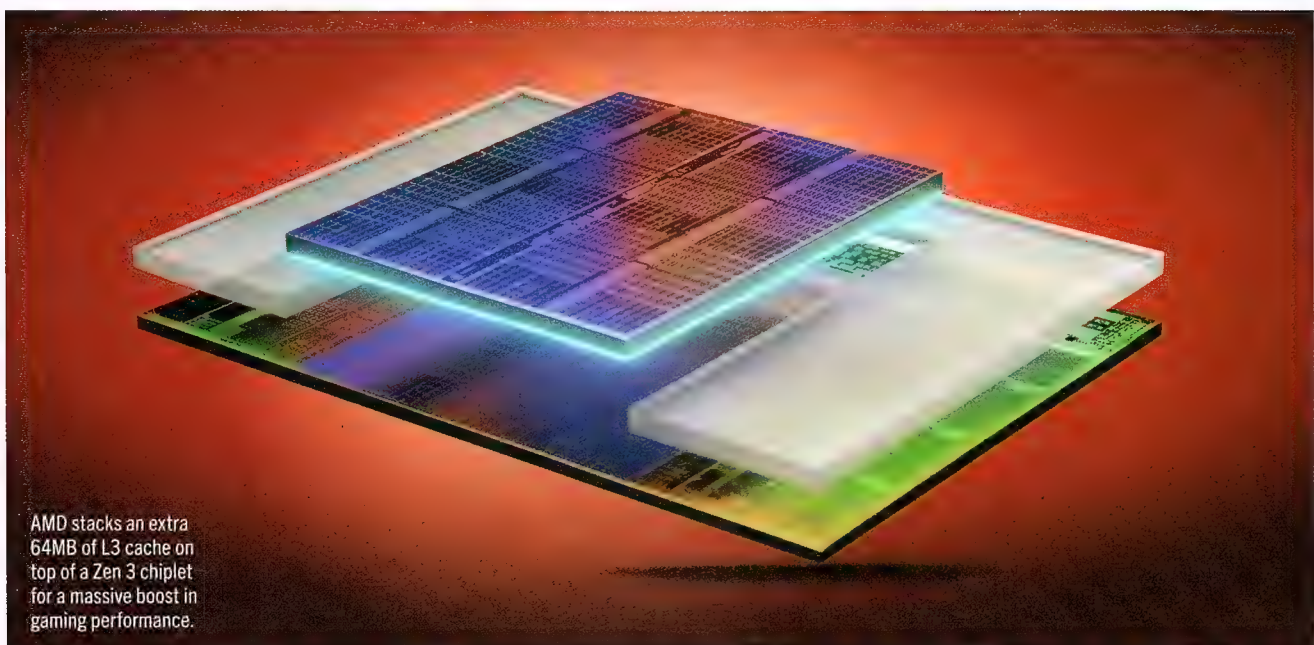
AMD claims an average boost of around 15 percent, but in our

test suite, we measured a 28 percent improvement in average frame rates at 1080p compared to the Ryzen 7 5800X. Not every game will show such huge gains, and the difference between the fastest CPUs when running higher resolutions becomes negligible. However, faster GPUs are coming, which should spread things out.

Even with those potential concerns, tripling the L3 cache clearly pays dividends. Technically, the Ryzen 7 5800X3D now reigns as the overall fastest CPU for gaming. Intel still has better single-threaded and multi-threaded application performance, which is something AMD will look to combat with its Zen 4 architecture. Given what we've seen with the 5800X3D, it's a safe bet we'll see more Ryzen processors with 3D V-Cache. Bring on the Ryzen 9 6900X3D.

Jarrod Walton ■

"AMD claims an average boost of around 15 percent, but in our test suite, we measured a 28 percent improvement in average frame rates at 1080p compared to the Ryzen 7 5800X."



AMD stacks an extra 64MB of L3 cache on top of a Zen 3 chiplet for a massive boost in gaming performance.

ONE MORE THING

Clouding over

Before you buy into a cloud-based system, says Jon Honeyball, you must prepare for failure.



The news that Insteon, purveyors of IoT smart home products, has suddenly shut down will come as an unpleasant surprise to its erstwhile customers. The servers are gone, as are the website's support pages. There is some hope that it will be possible to resuscitate the service to a minimal level, if only to allow existing customers to migrate data to a different service, but that remains a hope at this stage.

I'm not surprised that there has been a casualty like this. Any product that relies on an intimate relationship with a cloud service for it to function is at

"It's possible that Amazon might pull the plug on the entire Alexa infrastructure."

risk of that service failing or disappearing altogether.

We might wonder how this situation has come about. There is no intrinsic need for a cloud service to be involved with the core operation of an IoT device, but there is an interesting business model at play. For a start, it means the product can just call out to a cloud service somewhere hosted "out there", with no need for the smarts to be running within the local area

network. This makes deployment and set up easier.

Even better, for manufacturers, is that it gives them one central place to update capabilities and functionality for all their customers. No need to talk to a big bunch of local LAN controllers: just update the cloud server. If you have a local networking box, maybe to allow a protocol transition to Zigbee, then this box can be essentially dumb and closed to the user. And it's much easier for an app on your phone to communicate with the cloud server as it saves any pesky need for local LAN connection, VPN tunnels or any other kind of "at home, away from home" configuration hassle.

It's undoubtedly an effective business model, right up to the point where the cloud service disappears. Then you, the customer, are left with junk.

The easy answer is to say, "avoid any product that has any element of cloud functionality". But that is too simplistic and doesn't take into account a realistic evaluation of the sturdiness of the company involved. So, we must do our own realistic risk assessments. It's possible that Amazon might pull the plug on the entire Alexa

infrastructure, but I would suggest that it's pretty unlikely.

Compare and contrast this level of certainty with that of much smaller tier two, three and four suppliers. While they might well integrate into the top tier platforms such as Azure, they're still reliant on their own cloud services infrastructures. Consider my home security cameras: I am passionately convinced that these should be wired up using Ethernet cables, preferably with power coming from the POE standard. There should be a local network video recording solution that captures everything, 24/7. And there is no hook into a cloud service.

The failure of Insteon won't be a sole event. The ongoing supply chain constraints are putting extreme pressure on the smaller vendors. In the past the saying maintained "no one got fired for buying IBM". There must be a modern equivalent, whether that is Amazon, Apple, Google or another of the big players. Just don't fall in love with a relatively unknown vendor and put too many capabilities in the one basket. It might not be there tomorrow. ■
Jon Honeyball exists in one place: his local.



The source for tech buying advice

techradar.com

SPECIAL
OFFER

SPECIAL OFFER

Subscribe to APC

The go-to resource for PC enthusiasts



Simply scan the QR
code above with your
smartphone camera



All the convenience of *APC* delivered
direct to your door. Get the print edition
home delivered for a year for \$79

Save up to 47% off the newsstand price Get the print
edition home delivered 24 issues only \$139.00
– that's just \$5.79 per issue!

SPECIAL OFFER

APC digital edition also available

Subscriptions also available for Apple
and Android devices.

APPLE OFFER

Free 30 day APC
app subscription trial.
Read our latest issue
free today



The Apple edition for iPhone,
iPad and iPod touch
tinyurl.com/APCAPPLESTORE
From \$4.99 an issue

The Zinio edition for all
Android devices
apcmag.com
From \$4.99 an issue

Two easy ways to subscribe to APC magazine:

VISIT www.techmags.com.au or CALL (02) 8227 6486



SCAN ME

TERMS & CONDITIONS: This offer expires July 10th 2022, and is available to subscribers within Australia only. Please allow 6-8 weeks for delivery of your first issue. For full terms and conditions, see: <http://techmags.com.au/style/images/FutureTC.pdf> Please see our privacy policy on page 3. *Six issues for \$49, then \$49 charged to your credit or debit card every six issues thereafter on auto-renewal.playback); 32x22x1.7cm; 1.78kg.

CROWDFUNDING THE MILITARY

What Ukraine shows about the future of war

We're used to guerrilla tactics when it comes to on-the-ground fighting, but Russia's invasion of Ukraine has accelerated the use of their modern equivalent. Nicole Kobie reports.



Drones deployed to spot weaknesses in columns of tanks. Presidential addresses via Instagram, ministers asking favours via Twitter. A military using crowdfunding and cryptocurrency to buy equipment. The mismatched military might of Russia and Ukraine has sparked creative uses of technology by the latter, hinting at the future of warfare.

The Ukraine war is still dominated by traditional methods of massacre, be it missiles or tanks or even Molotov cocktails. But like the rest of our lives, war has been upended by the digital revolution. "I think this is the reality of war in the digital age, the world we live in now," said Neil Ashdown, researcher in cyber security at Royal Holloway, University of London.

Indeed, defence contractors and military organisations are often the first to shift to new technologies – or, in the case of the internet, fund their development in the first place. The most famous robots on YouTube are the parkour-running beasts from Boston Dynamics, a company sold by one-time owner Alphabet after staff protested at the military

potential of the designs. Even now, Microsoft is making headlines for working with the US Department of Defense on augmented reality.

But the technologies in use by Ukraine and its military are different: they're mainstream, everyday devices and apps that many of us use, too. Ukrainian President Volodymyr Zelensky shares presidential addresses from Kyiv via social media, while minister Mykhailo Fedorov – a former tech company founder – sourced satellite internet from Elon Musk and crowdfunded cryptocurrency over Twitter. And the Ukrainian military claims to have successfully held back Russia's war machines from getting too near Kyiv using off-the-shelf drones.

Mainstream tech

None of this is new, strictly speaking. Ashdown notes that ISIS has long used Telegram and cryptocurrencies, while drones aren't new on the battlefield. What is new is their use in traditional warfare. "We've seen these technologies be used... in different contexts around the world," said

Ashdown. "It is interesting to see [them] used in... a much more conventional conflict."

Commercial drones, for example, were always assumed to be useful in asymmetric conflicts where a developed army was operating against an insurgency, Ashdown

says, or where both sides lacked access to conventional weapons or systems. "It's been interesting to see that, for whatever reason, that has turned out to be incorrect," observed Ashdown.

Of course, the balance of military

might is heavily favoured in Russia's direction in this particular conflict, but Ukraine isn't just using every technique it can out of desperation – though as this war is seen as an existential threat, Ashdown notes, that is also happening – but because its military is using what works. In other words, Ukraine is exploiting drones, social media and more because they're effective in war.

"The technologies in use by Ukraine and its military are mainstream, everyday devices and apps that many of us use, too"



Above: Ukraine's use of drone technology has been vital in its reconnaissance.

Drones

The overhead photos of the 64km-long convoy of Russian tanks and trucks headed toward Kyiv showed up at the beginning of March, but the column never made it to the Ukrainian capital. The reasons for that are unclear, but Ukraine claims some of the credit is due to the work of a small team of specialist operators that use drones to pinpoint where to attack.

Known as Aerorozvidka (aerial reconnaissance), the 30-strong group began as a volunteer IT squad, founded by a former investment banker, Volodymyr Kochetkov-Sukach, who was killed in action in Donbas in 2015. Aerorozvidka perfected the use of off-the-shelf kit to target more conventional weapons, including off-road-vehicles to target the stalled Russian convoy, but now also uses its own drone designs and Elon Musk's Starlink satellite system, according to media reports.

Even without such dramatic tales, it's clear Ukrainian forces have been making use of drones because we've seen the footage. "A lot of footage of Russian tanks being destroyed available on social media appears to have been captured by drones," said Dr Afzal Ashraf, an international relations and security specialist at Loughborough University. "This indicates they will almost certainly have been used in a reconnaissance role by the Ukrainians."

The other side will also be using such devices, however. "Almost certainly, the Russians have employed drones for similar purposes and possibly for deploying ordinance against targets of opportunity," said Ashraf. "That is



Help Ukraine with crypto, don't leave us alone with the enemy

The community has already raised \$ 60 327 425 / \$ 200 000 000

Donate crypto to Ukraine to support people in their fight for freedom

Bitcoin Ethereum
Tether
Solana

everstake FTX KUNA

Top: The Ukrainian military has used modern technology to great effect.

Above: Crowdfunding, crypto and NFTs have all been employed to raise cash for Ukraine.

to say, targets such as leaders who might step outside a building for a short period. Attacking such targets requires a loiter capability which is not available in manned aircraft."

Social media

Want to know what's happening in Ukraine? Headlines dominate traditional news media, but soldiers are going viral by posting video clips directly from the field of conflict – and, in the case of Ukrainian farmers who swiped a Russian tank with a tractor, fields of crops, too – while Zelensky livestreams speeches and holds Zoom meetings with foreign governments.

Social media isn't going to prevent rocket attacks, but it can help win the hearts and minds of people outside Ukraine – and sway foreign governments into giving more assistance. "The one thing that every analyst who's looking at this would agree is that the Ukrainians have done very well at making their case," said Ashdown, adding that it's not only a PR win but a technical achievement to keep online amid the bombardment.

And Zelensky isn't just targeting world powers. "What's new and novel here is the extent to which, in addition to doing the traditional things of talking to international bodies and governments, the Ukrainians have been very effective at talking to people directly through social media," said Ashdown. "If you

look at some of the messaging from organisations like the Ukrainian National Guard, for example, they are posting pictures of their soldiers with cute cat memes. They are very aware of the kind of content that sells online." (It's worth noting that the same account has been criticised for sharing posts in favour of local alt-right groups, too.)

Zelensky's social efforts haven't necessarily been successful with achieving specific goals. "His main objective... has been to encourage direct involvement by NATO in the conflict," said Ashraf. "Much of Ukrainian social media commentary has targeted Western public opinion in an attempt to get the public to force their governments to intervene in Ukraine. In that aspect, social media has so far failed."

The president isn't the only one in the Ukrainian government using social media. Vice president and digital minister Fedorov has used Twitter to encourage a digital blockade against Russia, turning social media's "cancel culture" against companies that do – or did – business with Russia, pressuring them via digital activism to stop. So far, that's included getting Apple to stop allowing some Russian payments through Apple Pay and convincing the CEO of SAP to "gradually stop supporting their products in the occupant's companies," Fedorov tweeted. "And after our victory, SAP will open an R&D centre in [Ukraine]."

Crowdfunding

Another way social media has helped is with crowdfunding efforts, directly to the military as well as through fundraising and supporting refugees. The latter may sound like a standard war-time effort, but in this instance it's part of the wide-ranging nature of Russia's invasion. "It is very likely that the Ukrainian refugee crisis is part of Russian strategy to put

pressure on western governments through the economic and social drain that large numbers of refugees will place on Europe," said Ashraf. "In response, the UK's DEC appeal has had an unprecedented response in terms of donations. Figures I have seen appear to eclipse several recent major campaigns put together."

Using crowdfunding to finance conflict isn't new, with terror groups such as ISIS using the tactic. But Ukraine has made it possible to send money directly to its armed forces via a special account with the central bank.

Fedorov also shared addresses for Bitcoin and Ether crypto wallets on his Twitter profile, garnering hundreds of donations for the government worth more than \$9 million in a matter of hours. A month later, it had raised more than \$80 million.

And Fedorov has even found a use for NFTs, or non-fungible tokens, a way of selling digital ownership that has attracted artists and scammers alike. He's set up a digital museum of war called Meta History (metahistory.gallery), selling more than a thousand NFT artworks commemorating the events of the war worth more than \$780,000 at the time of writing.

One final money-raising effort of note has been direct aid to Ukrainian citizens. Through platforms such as Airbnb, many people booked accommodation in Kyiv and other cities through the app and then cancelled them so that the payment would still go through. Alongside the usual humanitarian appeals organised by charities, it has proved to be an efficient way of sending direct financial aid to people who would otherwise have had no income.

A step further

In April, Anonymous leaked the personal details of 120,000 Russian soldiers, but hacking has largely been missing from Russia's offensive to date. Ukraine has recruited civilian tech workers to build an "IT army" to help defend against such attacks.

"There's been an expectation that there would be much more use of offensive cyber operations in a way that would be visible to people," said Ashdown, in particular around Russia attempting to disrupt Ukrainian communications to its military forces or the wider world. "We still don't know at this stage enough to say reliably why we



Mykhailo Fedorov
@Fedorov_Mikhailo
Ukraine government official

A new batch of Starlink stations! While Russia is blocking access to the Internet, Ukraine is becoming more open to the entire world. Ukraine is the truth. The truth always wins. Thank you, @elonmusk, the Government of Poland, and Orlen.



haven't seen that, whether it was an absence of attempts to do this for whatever reason or whether there were attempts that were somehow defeated, either by good cybersecurity or other interventions."

Ashdown said that Western governments have warned that Russia could target its cyber attacks outside of Ukraine in response to sanctions, perhaps attempting to hack or disrupt the finance and energy sectors.

An unexpected use of technology has come in the form of facial recognition used by Ukraine to identify dead Russian soldiers. Clearview AI controversially uses facial recognition to identify photos it finds online, with a database of billions of images taken from the internet. Last year, an Australian court demanded Clearview AI delete images of Australian citizens saying it was a breach of privacy.

While Clearview AI positions itself as a tool for law enforcement,

Ukraine is reportedly using Elon Musk's Starlink satellites to stay online.

"Success won't be down to digital technologies, but smarter tactics, external support and a desperate will to survive"

the company offered its services to Ukraine for free, in order to let armed forces identify people at checkpoints and identify dead soldiers, according to a Reuters report (tinyurl.com/APC508CLV), although it isn't yet clear how the software is being used or even if it is being used.

Future of war – and Ukraine

There's a reason Ukraine is using so many different tactics: it has to. "Ukrainians... are viewing this as an existential conflict," said Ashdown. "I think your risk calculus as a government and your willingness to try things and to engage every tool in that box of statecraft is going to be much wider."

Given the availability of such tactics, and that most conflicts are unevenly pitched, it's no surprise that digital is the future of warfare. "These technologies aren't going to go away and their influence is only going to continue to expand across our societies – it would be surprising to think that warfare would escape this broader aspect of digital transformation," said Ashdown.

But that doesn't mean that Ukraine's superior use of social media will save it from Russia's forces. "There is a view that off-the-shelf and mainstream technologies have empowered non-state actors and weaker countries in terms of waging war," said Ashraf. "Certainly, when it comes to communicating globally, this has been a game changer. Discreet conflicts in any part of the world can now be viewed by an interested audience anywhere. This raises awareness and support for the weakened party."

"However, in-depth studies of recent wars indicate that it isn't the availability of technology but rather the superiority of strategy and a commitment to winning [that] has resulted in defeats for the most technologically advanced militaries in the world, as was seen in Vietnam, Iraq and Afghanistan, for example," added Ashraf.

In other words, in the end, Ukraine's success won't be down to digital technologies, but smarter tactics, external support and a desperate will to survive – but if social media can play a small part enabling Zelensky to lead the country to victory, those are tweets worth making. Regardless of the outcome of this war, the one thing that's safe to predict is that mainstream technology will continue to play a role in such conflicts, so long as we're foolish enough to keep having them. ■

THE FUTURE OF MAGAZINES



➤ Subscribe at www.techmags.com.au

Free delivery across Australia | Never miss an issue | Save money

THE A-LIST

The A-List

The best products on the market, as picked by our editors.

FIND THE BEST DEALS ON NEW GEAR AT [GETPRICE.COM/AU](https://getprice.com/au)

PREMIUM LAPTOPS

APPLE MACBOOK PRO 14IN

STUNNING CREATIVE POWER
Alongside its 16-inch sibling, this is simply the world's best laptop for demanding users. The amount of power on tap via the M1 Pro or M1 Max processor is staggering, and it's backed up by a terrific screen and stunning battery life. With all the ports you could ask for, the only negatives are its relative bulk (especially compared to the Air) and high price.

From \$2,999, apple.com/au



ALTERNATIVES

LG GRAM 17 (2021)

The combination of a 2,560 x 1,600 17-inch screen and 1.3kg weight – as well as a well-rounded specification – make this a great buy for homeworkers.

\$2,998, lg.com

APPLE MACBOOK AIR

If you don't need the power of an M1 Pro or M1 Max, "make do" with the M1 in the MacBook Air and enjoy its super-slim design and relatively light weight at a much lower price.

From \$1,499, apple.com/au

ASUS VIVOBOK PRO 16X OLED

Top notch components, an amazing OLED display and leading battery life make this an exceptional Ultrabook for creatives.

\$3,199, asus.com/au

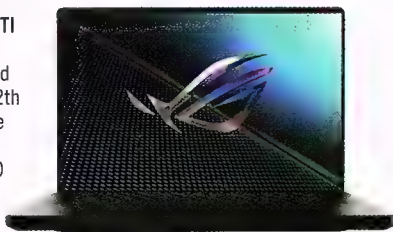
GAMING LAPTOPS

ASUS ROG ZEPHYRUS M16 (2022)

19-12900H AND AN RTX 3070TI

2022 will see an update for all mainstream gaming laptops, and Asus is first to jump in with a 12th gen Core i9 CPU to give 16-core support to the RTX 3070 Ti graphics (a Core i7/RTX 3060 variant costs \$2,999). While battery life is only average at around six hours, this laptop's final triumph is fitting a gorgeous 16-inch screen into such a compact chassis.

\$4,499, asus.com/au



ALTERNATIVES

ASUS TUF GAMING A15 (2021)

The TUF Gaming A15 is a great choice if you need both power and portability, thanks to a Ryzen 7 5800H processor and RTX 3070 graphics.

\$2,399, asus.com/au

ASUS ROG STRIX SCAR 15 (2022)

A no-holds barred 15.6in laptop that gets the most from its i9-12900H CPU, RTX 3080 Ti, 32GB of DDR5 RAM and 2TB SSD.

\$5,299, asus.com/au

ASUS ROG STRIX SCAR 17 (2022)

An RTX 3070 is the star, but it's backed by a high-quality 15.6-inch 165Hz screen, Ryzen 7 CPU and a solid aluminium chassis.

\$2,299, asus.com/au

BUSINESS LAPTOPS

DYNABOOK PORTEGE X30W-J

THE BEST CONVERTIBLE MONEY CAN BUY

Not only is this 2-in-1 convertible ludicrously light and slim, but it also offers a quiet keyboard, performance fireworks, ports a-plenty, a natural-feeling touchscreen and a battery that will see you through a busy working day. Dynabook by name, dynamite by nature.

\$2,369, anz.dynabook.com



ALTERNATIVES

NEW ENTRY

HP ELITEBOOK 840 AERO G8

HP's premium range of laptops is worth the extra for its top-quality screen, and it's backed up by HP's Wolf Security and a slim, all-metal chassis.

\$2,209, hp.com/au-en

LENOVO THINKPAD X1 CARBON GEN 9

A business laptop with heaps of luxury, especially if you choose the top-end model with a 3,840 x 2,400 screen.

\$2,389, lenovo.com/au

DELL XPS 13

Dell has updated the gorgeous XPS 13 with Intel's 11th-generation Core chips to great effect. The 13.4-inch screen, touchpad and solid keyboard are similarly sumptuous.

From \$1,518, dell.com

EVERYDAY LAPTOPS

ACER SWIFT 3X I7 EXCELLENT PERFORMANCE AT AN APPEALING BUDGET PRICE

The headline feature of Acer's new Swift 3x is undoubtedly the fact that it features Intel's new discrete GPU – the Iris Xe Max Graphics. The Swift 3x is available through Harvey Norman as either an i7 with a 1T SSD, or a Core i5 model, with a 512GB SSD.

From \$1,049, acer.com.au



ALTERNATIVES

LENOVO YOGA SLIM 7 PRO

A powerful, well designed ultrabook with an awesome OLED screen for a good price. The original 2-in-1 bends into a new clamshell shape.

\$1,949, lenovo.com

HP ENVY 13 (2020)

It may not be the world's most exciting laptop, but the Envy 13 is a compact and forward-looking machine that's ideally suited to these homeworking times.

\$1,699, store.hp.com

MICROSOFT SURFACE LAPTOP GO

A superb travelling companion, the Go offers all the power you need in a stylish and well-built 1.1kg chassis.

\$1,179 microsoft.com

CHROMEBOOKS

ASUS CHROMEBOOK FLIP C436F

FLEXIBLE LAPTOP FOR \$1,419

The Flip C436F is a fast, flexible laptop with a slim magnesium alloy chassis that's easy on the eye. With a 256GB SSD, a Core i5 processor and fantastic 14-inch Full HD screen, it's a fine choice for demanding users.

\$1,419, amazon.com.au



ASUS CHROMEBOOK CX9

Aimed squarely at business users, this exceptionally quick machine – with a Core i7 processor, 16GB of RAM and a 512GB SSD – drips quality throughout its aluminium alloy chassis. Add a glossy 4K 14-inch screen, plus a low weight of just 1.05kg, and it justifies its high price. \$1,579, asus.com/au

LENOVO IDEAPAD DUET

The Chromebook answer to Microsoft's Surface tablets, this is a seriously versatile device – albeit not the speediest (although we never found it to be painfully slow while carrying out everyday tasks). For this price, and with a 16hrs 14mins battery life, the Duet is a great choice.

\$447, lenovo.com/au

TABLETS

APPLE IPAD PRO 12.9IN (2021)

M1 POWER IN YOUR PALM FROM \$1,199

Blurring the boundaries between laptop and tablet like never before, the M1-powered iPad Pro 12.9-inch is every bit as fast as we expected – and the "Liquid Retina XDR" display is simply phenomenal. apple.com/au



APPLE IPAD (2021)

Apple performs its usual trick of upgrading just enough to keep the iPad affordable and up to date, without treading on the toes of its more luxurious stablemates. The big bezels remain, but a faster processor, more storage and improved camera all add to its appeal. From \$449, apple.com/au

SAMSUNG GALAXY S8 ULTRA

The Samsung Galaxy Tab S8 Ultra is an enormously impressive tablet. It makes a fantastic first impression with its gorgeous screen and thin body, and is great for multitasking. If you want the best Android tablet going, there's no question at all that this is it.

\$1,598, samsung.com

EVERYDAY MONITORS

PHILIPS BRILLIANCE 346P1C

34-INCH CURVED DOCKING. No-one can match Philips for its mix of quality, features and value, especially when it comes to curved MVA monitors such as this. It's great for casual gamers and busy workers alike, with USB-C docking and superb colours.

\$849, philips.com.au



EIZO FLEXSCAN EV2480

Businesses in particular will love this easy-to-roll-out 24-inch monitor, with its exceptional five-year warranty, USB-C port for easy docking, excellent viewing angles and delicious whites. And it has the best OSD around.

\$699, eizoglobal.com

DAHUA DHI-LM28-F420

This affordable 4K monitor might not offer much in the way of menu options or high-end gaming perks, but it offers impressive resolution and colour for a fraction of the price you'd normally pay.

\$269, dahuaaustralia.com.au

PROFESSIONAL MONITORS

EIZO COLOREDGE CG319X

CREATIVE MASTERCLASS, \$7,119

As the price indicates, this monitor is for heavyweight creatives who demand the best in every discipline: HDR video editing, print layouts, professional photography and more besides. With superb coverage and accuracy across all spaces, plus a built-in calibrator, it justifies the investment.

\$7,119, eizoglobal.com



BENQ PD2725U

By no means a cheap 4K 27-inch monitor – unless you compare it to the Eizos – but it marries all-round quality with ease of use thanks to a puck that allows you to quickly move between settings. You can even daisy chain a second Thunderbolt 3 monitor for a monster setup.

\$1,799, benq.com

EIZO COLOREDGE CG279X

Designers who need to work across different disciplines will love how easy it is to switch between the Adobe RGB, DCI-P3 and sRGB colour spaces using the Eizo's fantastic OSD. It's certainly not cheap for a 27-inch 1440p monitor, but it's packed with quality.

\$3,095, eizoglobal.com

HOME OFFICE PRINTERS

EPSON ECOTANK ET-1810

BACK TO BASICS

There's nothing flashy about this bottle-fed inkjet: it's there to churn out pages at a decent rate (8.8ppm for black text) for a low price. It comes with enough ink for 4,500 black pages and 7,500 in colour, but refills are cheap. Just don't expect features like duplex printing.

\$299, epson.com.au



CANON PIXMA PRO-200

Yes, it's big and it's expensive – and you don't even get a scanner – but the Pixma Pro-200 means that you can print A3 photos with glorious colour accuracy and detail. If you're after an office workhorse, look elsewhere, but it can't be beaten on photo quality.

\$809, canon.com

BROTHER MFC-J4540DWXL

Home workers will love this inkjet all-in-one. It combines an incredible range of features with all the connectivity you need and extreme ease of use. Output quality is fine, it offers the best cloud support around and the high-capacity ink pack could keep you going for years.

\$420, brother.com

WIRELESS ROUTERS

■ NEW ENTRY

SYNOLOGY RT6600AX**FAST & LADEN WITH UNIQUE FEATURES**

Fast, well-featured and secure, the Synology RT6600ax is as perfect for professionals and prosumers as much as it is for SMBs and smart homes.

\$599, synology.com/au

**ASUS RT-AX82U**

The impressive RT-AX82U punches well above its price when it comes to raw Wi-Fi 6 performance and includes a fistful of useful features – such as an ultrafast 20Gbits/sec USB connector, outbound VPN support, site-blocking and a host of parental controls.

\$320, asus.com/au

HUAWEI WS7200

This affordable Wi-Fi 6 router delivers consistently fast wireless speeds, broad coverage and a modest speed boost for newer hardware – and the Router 3 has a cute design too. If you need more range, you can pick up a second unit to use as an extender.

\$120, huawei.com

MESH WI-FI

■ NEW ENTRY

TP-LINK DECO X90
SUPERB WI-FI 6 MESH

Welcome to the new generation of Wi-Fi 6 meshes, with greater range and consistent speeds for both upload and downloads.

TP-Link reckons these two units will cover a six-bedroom house, and they each include 2.5GbE ports too.

\$699, tp-link.com

**TP-LINK DECO X20**

The price below isn't a typo: the Deco X20 makes it possible to upgrade your home network to Wi-Fi 6 – as well as manage its security – for the price of some standalone routers. The included HomeCare functions are also a great bonus for households where lots of devices are fighting over the bandwidth.

\$199, tp-link.com

ASUS ZENWIFI AX

The interface and design certainly aren't the prettiest (the nodes look like mini space heaters, while the charcoal version is straight out of the 1980s), but if you're after strong performance, great features and plenty of expansion potential, the ZenWiFi AX is a compelling prospect.

\$949, asus.com/au

NAS SERVERS

QNAP TS-130**SIMPLE HOME NAS**

An above average CPU and RAM combo, solid features and affordable price make the QNAP TS-130 worth considering. Alternatively there's the two bay TS230 which features the same CPU, with 2GB of RAM, dual drive bays, and an extra USB port on the front for a modest \$50 price increase.

\$250, qnap.com

**ASUSTOR NIMBUSTOR AS5304T**

This is a hugely powerful four-bay NAS that will be overkill for most people – not just due to its speed but also its slightly intimidating user interface – but techies and gamers should investigate the Nimbustor AS5304T for both its speed and flexibility.

\$799, asustor.com

SYNOLOGY DS1019+

This five-bay NAS includes many of the features that make the DS218+ to the left such an attractive buy: a superb selection of apps, an elegant hardware design and a good deal of power. And those five bays make it perfect for RAID5 configurations, or Synology's own Hybrid RAID.

\$1,249, synology.com

SECURITY SOFTWARE

F-SECURE SAFE

F-Secure concentrates on the basics: faultless protection with minimal impact on your system's performance – for a low price.

1-3 PCs, 1yr, \$99.99, f-secure.com



■ NEW ENTRY

NORTON 360

Consistently on the podium in our group tests, and loaded with an abundance of genuinely useful features, including a VPN and generous cloud backup.

1 PC, 1yr, \$79.99, nortonlifelockpartner.com

AVAST FREE ANTIVIRUS

For the second year running, Avast is our top pick for free antivirus software – it's simply lighter on its feet than Microsoft Windows Security, whilst offering fewer false positives.

Free, avast.com

VPNs

NORDVPN

NordVPN provides consistent and fast speeds, serious security, great support for video-streaming services and some cost-effective subscription rates.

\$59 per year, nordvpn.com

**PROTONVPN**

ProtonVPN provided one of the best free offerings of all the VPNs in our group test, including unlimited data, but upgrade to benefit from even faster speeds and many more options.

Free, protonvpn.com

SURFSHARK

A strong rival to NordVPN, especially if you're willing to commit to its two-year contract. It's fast, cheap and a fine choice for people who like to switch to US streaming services.

\$66.34 for one year, surfshark.com

PASSWORD MANAGERS

BITWARDEN

Bitwarden has a huge advantage: it's free. It isn't as slick as some paid-for rivals, but it can sync passwords across all devices for no extra charge.

Free, bitwarden.com

**DASHLANE**

A manager that's ideal for beginners, and it even builds in an unlimited (if basic) VPN service. Note you may prefer to buy the Family plan (\$60 per year) as this extends the service to six people.

\$55.99 per year (Premium), dashlane.com

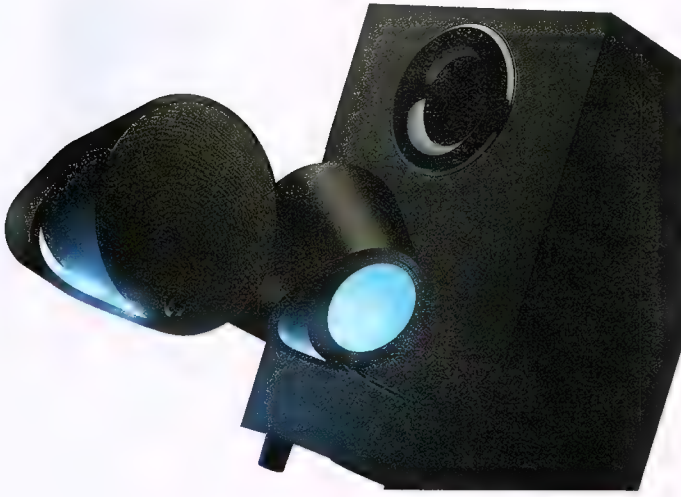
1PASSWORD

1Password is targeted at technically minded users who are looking for the last word in security. It even offers a Travel Mode that may ease your mind if surrendering your phone to customs officials.

\$54.99 per year (individual), 1password.com

The top five PC speaker systems

While there are plenty of headphone warriors out there, a good speaker system still has its place for gaming, music, or even just watching YouTube. There are loads of different options, from dual stereo speakers to complete surround systems, which is why we've tried to pick the best options across the various price points and categories here. But fear not, for no matter which option you choose, these systems all sound great.



1

LOGITECH G560

These Logitech speakers look great and sound fantastic, thanks to serious volume levels and a bulky subwoofer that creates an immersive soundstage. The RGB lighting is based on Logitech's Lightsync system and it also works with your phone over Bluetooth.

\$300, www.logitechg.com

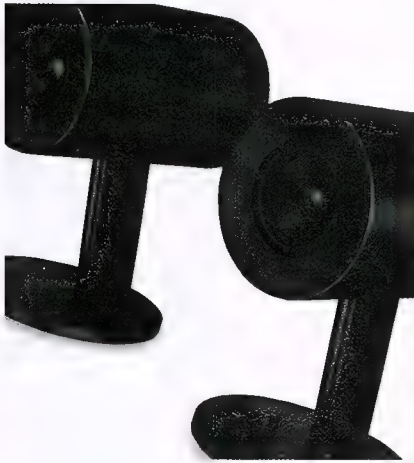


2

CREATIVE PEBBLE PLUS

If you primarily use headphones but want a speaker option, the Creative is a fantastic choice. It's a full 2.1 system with a separate subwoofer to drive the bass. The two pebble speakers are small, but sound crisp and go relatively loud. They're powered by USB, saving plug sockets at your desk.

\$70, www.creative.com



4

RAZER NOMMO CHROMA

This stylish offering is a 2.0 speaker system with no subwoofer, making it the best option for those short on space. The speakers are large, but they exude quality, with a rich, deep sound. There's also a headphone-out port and subtle RGB lighting around the base.

\$180, www.razer.com



4

LG ULTRAGEAR GP9

This wireless Bluetooth soundbar from LG is pricey but its features justify the price. As a PC speaker, it sits neatly underneath a monitor and creates stereo or virtual surround sound. But it's also a battery-powered Bluetooth speaker that can pair with a phone for five hours of party-starting music or sit under your TV. There's an app to control EQ settings and RGB lighting, plus a built-in microphone for voice chat.

\$800, www.lg.com



4

LOGITECH Z906

A 5.1 system isn't for everyone, especially as these rear speakers are wired, but if you love the cinematic experience on your PC, this is the speaker system to go for. It's THX-certified and will decode Dolby Digital and DTS, and provide a total of 1000W of power from its five speakers and subwoofer. This is ideal for anyone running a media centre PC, as it comes with various audio inputs for multiple devices, plus a remote control to switch between them.

\$500, www.logitech.com

HEAD TO HEAD

OBS Studio vs. XSplit Broadcaster

Which live stream app is better?

■ OBS STUDIO | Free | www.obsproject.com

■ XSPLIT BROADCAST | XSplit Broadcast, free. XSplit Broadcaster Premium, \$7/month, \$84/annually or a one off payment of \$280 | www.xsplit.com

Live streaming is no longer just a niche corner of the internet, with the huge increase in its popularity over the past decade pushing it to vast global audiences and making it one of the most popular forms of online video. The live aspect of streaming brings in the anticipation and excitement offered by live TV but with the opportunity for anyone to create their own content. Whether it's live streaming games, tournaments, chatting, IRL videos, talk shows, podcasts, music, and even ASMR, there is an almost infinite amount of content available.

As a result, the production side of streaming has gone way beyond just hitting a broadcast button and talking down the microphone – audiences expect more. To stand out from the crowd, you'll need to use live streaming software to polish your content and create a reputable design that oozes quality. Just like high-quality thumbnails on YouTube videos, a well-designed stream layout can bring in viewers. It shows your audience that you've put a lot of time and effort into your stream, just like how making an interesting background in your setup does too.

The actual video resolution has to be on par with the visual effects, so using a streaming application can make sure you tweak your stream to your liking. It's a great way to build up an image and style that you may become recognised for. Of course, your content still has to be relevant, engaging, and entertaining – and if it is all three, you won't want to be let down by a low-resolution stream, poor audio, or a basic layout. OBS and XSplit are powerful streaming applications that are more than enough to create a slick-looking stream, so which one should you choose?

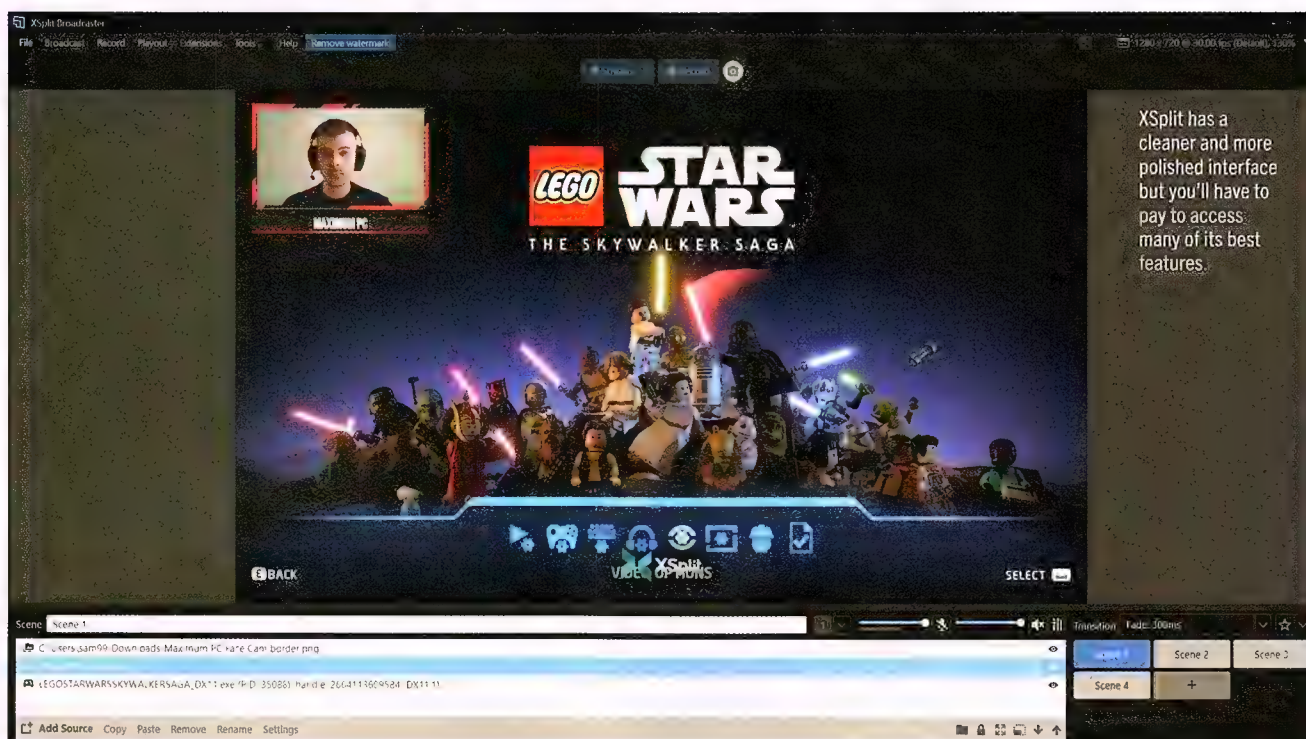
If you're new to the streaming world, choosing software could be tricky. You want a program that's quick to pick up and easy to navigate, yet has the potential to be used more intensively down the line. If a program is too heavy and busy from the get-go, it can become overwhelming and even put you off the idea entirely. When jumping into both of these programs, visually, XSplit has a cleaner user interface than OBS. That said, both programs don't have the most striking of designs. The layout on XSplit provides an efficient and simplistic use of space that feels more straightforward than OBS as the latter

is more cluttered. Both programs follow a similar layout with the main streaming window in the center of the workspace, your scenes, sources and audio controls below, and the rest of the settings in the top taskbar.

Likewise, with XSplit's design, you have bold buttons to control stream, record, and screen capture at the top, whereas in OBS, these important actions are hidden away in the bottom right corner. When you get more familiar with these, it becomes second nature but, from a beginner's point of view, the most important options should be easily accessible.

Both of these programs fundamentally achieve the same goal. They allow you to capture video from a source or recording and push that to a live streaming service such as Twitch, YouTube, or Facebook Live. In regards to streaming services, OBS has an output of around 90 different streaming platforms, with the ones listed above being just the most popular ones. XSplit, on the other hand, keeps things a bit more focused with 22 sites upon which to stream. So for streaming options, OBS has the upper hand over XSplit, it's just whether or





not you will ever use the less popular streaming sites. Thankfully, in both applications, it is easy to link your streaming accounts to the software to live stream quickly. After the first setup, it's as simple as hitting a button, so efficiency is solid for both applications.

To test out the usability of both applications, we tried to create the same simple layout in each – a game recording, with a facecam in the corner and a custom border around it. This is an easy way to make your layout more appealing and to have a nice contrast from your gameplay to your camera. On both platforms, you can create scenes, in which you can edit a design and layout. Then you can create another scene to focus on something else.

For example, we created three separate scenes on each application. The first scene contained gameplay, facecam, and a border around the facecam. The second scene contained the gameplay, and the third scene contained a facecam for closeups and when you are talking to your audience in between games. This is a fairly simple setup and we easily managed to replicate it in both programs. XSplit was slightly more intuitive than OBS again, due to its more simplistic user interface. So, for creating a scene and a layout, XSplit takes another point in this battle.

"As for features, both are competitive. There is one initial difference between the two though – OBS Studio is free."

As for features, both are competitive. There is one initial difference between the two though – OBS Studio is free. Unfortunately, to use XSplit Broadcaster properly, you will need the premium version, which has three options. You can pay monthly at \$7, annually for \$84, which makes it a more affordable option at \$7 a month, or you can buy a lifetime subscription for a one-off payment of \$280. Either way, there is still a big cost difference when compared with OBS. There is a free version of XSplit, however, your videos will be watermarked if you don't pay, and you're limited to a maximum of four scenes. As you'd expect, most of the best features are

hidden behind a paywall – the premium version offers a much richer program, including multi-streaming, unlimited resolution, unlimited scenes, source transitions, projector mode, and more.

As for what OBS offers for free, there is no watermark and you can achieve the same outcome, it just takes slightly longer and isn't as clear-cut as XSplit. The question is then, is XSplit worth paying monthly for over OBS? This depends on what level you are as a streamer. If you stream for fun and games and see the activity as a hobby, then OBS is all you'll need. It's still a capable and powerful program, and for the most part, is fairly simple to use.

On the flip side, the outdated and raw design hinders the application and means it's not as user-friendly as XSplit Broadcaster. If you're using this program frequently and taking live streaming down a more commercial route on Twitch or YouTube, then XSplit would be our choice. As you'll be using it more frequently, the easier-to-use application will certainly help with efficiency and reward you in the long run.

So which one is the winner? The short answer is OBS, although it is marginal. We aren't fans of the application's basic design but it offers many of the same features as XSplit, only without the cost. XSplit won't break the bank, but why have yet another subscription service taking a monthly bite out of your bank balance when there's a free alternative? Both apps have powerful editing tools, can create high-resolution streams, and broadcast to a multitude of services. It just depends on what type of streamer you are.

OBS Studio Open-source community, simultaneous recording and streaming, free.
Sam Lewis

★★★★☆

XSplit Broadcaster User friendly interface, stream delay feature, clean design, appropriate for both gaming and business.

Sam Lewis

★★★★☆

TECHNOTES

Gadgets

Nice little things



1

LG DualUp

\$1,299 | [lg.com](https://www.lg.com)

Kitted your PC out with several monitors to up your multitasking game? Turns out you've actually been doing it all wrong – at least, that's what the LG DualUp would have you believe. This unusual monitor is shaped like two 21.5-inch displays stacked on top of each other, meaning no more craning your neck side to side, scanning across your screens to see all your work.

Although LG says that's better for your neck, the 16:18 ratio means you'll still be looking up and down fairly frequently. Still, it could work really well in certain scenarios, for example by allowing video editors to fit more content on their screens at once.

2

Samsung
The FrameFrom \$595 | [From samsung.com](https://www.samsung.com)

Samsung's The Frame – known as one of the brand's "lifestyle" TVs – is part TV, part interactive art gallery. At CES 2022, it was updated to make that art look even better thanks to a new anti-reflective coating. Samsung claims this is glare-free and can even mimic canvas, making displayed art look even more lifelike and true to the real thing. And if you're tempted to reach out and touch it? There's no need to worry, as it now has an anti-fingerprint coating too.

Previously, The Frame included an art store that let you buy artwork and download it directly to the TV. Who needs to visit museums when you have one of these TVs at home?



3

Razer Phone Cooler Chroma

\$69.99 From [razer.com](https://www.razer.com)

Devices that try to keep your phone icy cold have been around for a while, but Razer's Phone Cooler Chroma is the first to use the magic of MagSafe to hold itself in place. Just pop it on the back of your phone and it stays put, no need for bulky frames that get in the way. If you regularly test your phone to its limits, heating it up in the process, that could be a very positive thing.

And, this being Razer, the device is festooned with RGB lighting, letting everyone know you're cooling your phone in style (or lack of style, depending on your taste).



4

NASA Mercury Hasselblad 500C No. 9

US\$4,800 From [spacecamera.co](https://www.spacecamera.co)



Starting in 1962, NASA began taking Hasselblad cameras into orbit to document the depths of space, with the cameras being heavily modified to survive the rigors of weightlessness. Unnecessary extras like the leather covering and viewfinder were removed to reduce some of the bulk, and the cameras were also painted in anti-reflective black paint to minimise reflections. Now, you can get your hands on a working replica of one of those cameras, all for the rock-bottom price of US\$4,800. It's built to be just like the original and comes with an 80mm f2.8 lens too.

5

Samsung The Freestyle

\$1,295 From [samsung.com](https://www.samsung.com)

The techno-hipsters of the world would have you believe projectors are old hat. Smart speakers? Passé. Don't even get them started on ambient lighting. But a device that combines all three? Now that's more like it.

Unveiled at CES 2022, Samsung's The Freestyle is exactly such a device. Its full HD projector is lightweight at 1.80 pounds, and its compact shape makes it portable. It also has a viewing angle that's adjustable by 180 degrees. When it's not beaming out movies, you can use it to cast ambient backgrounds that create whatever mood suits the occasion. And there's a smart Alexa speaker built into it that blasts audio in 360 degrees.



ULTRABOOK

MSI Creator Z17

MSI's new creative professional Ultrabook has a 3070 Ti, but can it handle this kind of power?

■ \$5,499 | au.msi.com

We love it when tech manufacturers attempt to break new ground and try something outside of the products that usually make them money, but we feel like MSI's attempt to capitalise on the creative laptop market should probably be nearing an end. The 2021 Creator Z16 that we tested in APC 501 was a substandard imitation of a two year old MacBook Pro 16 and while the new Creator Z17 doesn't suffer from the same issues, it succumbs to others in a pretty major way.

Back when Nvidia first released its 30 Series GPUs, we flagged that vendors now had control over how much power they would allocate to the graphics cards, a detail that meant a laptop with a 3080 GPU could end up performing worse than one with a 3070 if it wasn't given enough cooling architecture and power. The MSI Creator Z17 is perhaps the most obvious example of this we've seen to date.

The \$5,499 Creator Z17 costs as much as it does because of the Nvidia GeForce RTX 3070 Ti it carries, but since this device is intended to be a thin and light 17-inch Ultrabook it doesn't have the cooling apparatus to run a GPU that powerful. The 3070 Ti on the Creator Z17 has a maximum thermal design power (TDP) draw of 95W, which is more than 30 percent lower than an otherwise identical 3070 Ti with a TDP of 150W on a device like the MSI Raider GE76 we reviewed last issue (APC 507). Almost all of this power reduction translates into performance loss, meaning that the Creator Z17 is only capable of between

"Since this device is intended to be a thin and light 17-inch Ultrabook it doesn't have the cooling apparatus to run a GPU that powerful."



■ SW11 Pro; Intel Core i7-12700H CPU; Nvidia GeForce RTX 3070 Ti GPU (95W); 32GB RAM; 2TB SSD; 88Wh battery (5h 8min 1080p movie playback); 38.2 x 26 x 2.6cm; 2.49kg.

72 and 78 percent of what you get on the MSI Raider GE76.

Even against the inferior RTX 3070 on the MSI Crosshair 15 (page 36) the Z17's underpowered 3070 Ti is, on average, 11 percent behind that, thanks to the 45W power gap. MSI could've used a Nvidia GeForce RTX 3060 with a 95W TDP in this exact configuration without any perceptible impact on graphics or battery life. The only difference is that the device would have been well over a thousand dollars cheaper.

The only configuration available locally comes with an i7-12700H CPU, 32GB of RAM and a 2TB SSD which

would be a well balanced configuration had there been enough thermal dissipating capacity to run the GPU at full tilt. The unit we tested also came with a large 88Wh battery, but, unfortunately it only lasted between four and five hours depending on the task. So you shouldn't expect the Creator Z17 to last a full working day, no matter how light your workflow is.

The 17-inch screen offers professional level colour specs and while it really could've done with a 4K screen, the 220 PPI, 16 by 10 display is still high quality and looks great.

MSI has attempted to create value by adding a stylus, but the laptop's hinge doesn't fold back far enough for there to be any screen position in which a stylus could be useful. We have no issue with the trackpad and the keyboard is nice to type on, but these details will only go so far in making up for the device's considerable limitations.

A professional laptop with an expensive GPU that dramatically underperforms.

Joel Burgess

★★★★☆

	MSI Creator Z17	MSI GE76 Raider (2022)
PCMark 10 - Overall (score)	6,735	7,618
1080p movie playback (HH:MM)	05:08	06:06
Cinebench R23 - CPU (Score)	10,032	17,118
3DMark Time Spy (score)	8,194	11,247
The Division 2 - 1080p Ultra (fps Av.)	79	102
F1 2021 - 1080p Ultra (fps)	97	128
CrystalDiskMark Read (MB/s)	7,079	6,584
CrystalDiskMark Write (MB/s)	5,116	5,085

GAMING LAPTOP

MSI Crosshair 15

Is MSI's new gaming laptop range a true marksman or just another mediocre laptop to cross off the potential list this year?

■ \$3,599 | msi.com

The Crosshair is one of MSI's newer gaming laptop ranges that launched alongside the recent Creator series devices. Other than the unique yellow paint job, which is a *Rainbow Six Extraction* collaboration, the most unique feature on this gaming rig is the display. The 15.6 inch QHD screen offers full DCI-P3 colour coverage according to the marketing material, which would be a great feature for more immersive gaming if there was any way for the system to actually use it.

Unfortunately there must've been some miscommunication within MSI's engineering department, since this colour accurate display has only been given the capacity to process and reproduce SDR images using an 8-bit sRGB colour profile, rather than the more rich 10 or 12-bit HDR formats. This means you can forget about the 26 percent more colour that this display is theoretically capable of, because the way it's been connected to the motherboard means it's actually likely to look like it has more compressed colours than a standard 100 percent sRGB screen.

Putting aside this colossal oversight, the screen does at least offer 165Hz refresh rates, but it comes without any form of Freesync or G-Sync compatibility. The absent screen tearing tech will be disappointing for anyone serious about first-person-shooters – *Rainbow Six Extraction* or otherwise – since you're likely to get a whole bunch of screen tearing and other unwanted artefacts. This is a missed opportunity since a lot of the underlying tech is already in the device.

The Crosshair 15 comes in one of two main configurations, built around either an Intel i7-12700H CPU or an i9-12900H processor. Both these new releases from Intel are 14-core processors comprising six high



■ W11 Home; 15.6-inch 165Hz display at 2560x1440 pixel resolution; Intel Core i7-12700H CPU; Nvidia GeForce RTX 3070 GPU (140W) GPU; 32GB RAM; 1TB SSD; 86Wh battery (3h 7min PCMark 10 Home Office); 35.9x25.9x2.7cm; 2.25kg.

performance cores and eight efficiency cores that switch dynamically amongst themselves to achieve the best performance to battery life at any given time. The i7 is typically paired with 16GB of RAM and a Nvidia GeForce RTX 3070 GPU that lands at \$3,499, but you can get a configuration with 32GB of RAM for about \$100 more from different outlets. Otherwise the i9, 16GB RAM configuration comes with an RRO of \$3,799.

These prices are thousands more than what you can get when buying similarly specced laptops with 11th Gen processors, which is a lot when you consider it's only one generation

away, but Intel's redesigned chips offer far more cores that dramatically improve performance and efficiency. Early results show 10-25 percent gains from the i7-11800H to the i7-12700H CPU and this performance jump can be anywhere up to 50 percent improvement when compared with the i9-12900H using some benchmarks.

Graphically the Crosshair 15 performs as well as expected thanks to an RTX 3070 with a 140W potential power allocation. This generous peak wattage means you won't see any performance loss as you do on some of today's laptops (see opposite page MSI Creator Z17) but it also only achieved only a maximum of four percent improvement over an Alienware M15 R5 with a 125W 3070 that we tested last year across all our GPU benchmarks. Still this is enough to guarantee 60 plus fps on any current game using 1080p Ultra settings.

	MSI Crosshair 15	Alienware M15 R5
PCMark 10 - Overall (score)	5,800	5,953
Max CPU Temperature (C)	99	103
PCMark 10 - Work Battery (HH:MM)	03:07	02:53
HWBot x265 - 1080p (Ave fps)	41.05	58.805
3DMark Time Spy (score)	10,003	9,596
The Division 2 - 1080p Ultra (fps Av.)	81	81
CrystalDiskMark Read (MB/s)	3,602	3,128
CrystalDiskMark Write (MB/s)	3,450	3,128

An acceptable gaming laptop that would've benefited from HDR integration and better GPU thermal design
Joel Burgess

★★★★☆

GRAPHICS CARD

MSI Radeon RX 6750 XT Gaming X Trio

An overclocked 6700 XT?

■ \$1,059 | www.msi.com

Much like the RX 6650 XT and RX 6950 XT, the RX 6750 XT is a refresh of the RX 6700 XT. As mid-range RDNA 3 cards are perhaps a year away, it makes sense for AMD to give it a mid-life tizzy up. Add some faster memory, up the clocks and TDP a little and make a few firmware level tweaks, and voila, meet the RX 6750 XT. Its purpose is to compete with Nvidia's GA104 models, the 3060 Ti, 3070 and 3070 Ti. At this tier, it needs to be capable of high frame rates at 1440p while offering competitive value for money.

The 6750 XT is built with the Navi 22 GPU. It packs 2560 shader units into a 7nm 17.2 billion transistor 335 mm² die. It has 12GB of 18Gbps memory, which delivers a total of 432GB/s of bandwidth over a 192-bit bus. This compares to the 16Gbps and 384GB/s of the 6700 XT. It includes 96MB of Infinity Cache. Unlike the lower tier 6000 series cards, the 6700 XT includes a full PCIe 16x connection. The TDP of the card has been increased by 20W, from 230W to 250W.

We received MSI's RX 6750 XT Gaming X Trio for our review. As the name suggests, the Trio is a triple fan cooler and cooling the Navi 22 GPU is well within its capabilities. It's a big card, but it's all but silent and a load temperature of just 64C is outstanding for a 250W GPU. It comes with a boost clock of 2623MHz, and during our



■ MSI Radeon RX 6750 XT Gaming X Trio. 2560 Shader Cores; 2554MHz Game Clock, 2623MHz Boost Clock; 12GB 18Gbps GDDR6 memory, 432GB/s Memory Bandwidth; 3x DisplayPort 1.4a, 1x HDMI 2.1; 2x 8-pin Power Connector, 250W TDP.

testing, the card was able to hold a clock of 2,695MHz. Well done MSI. It comes with a single HDMI 2.1 and triple DP 1.4a ports. Dual 8-pin power connectors deliver more than enough juice to power the card.

When it comes to performance, the RX 6750 XT is essentially an overclocked 6700 XT. That's not a bad thing as the 6700 XT

isn't exactly a slouch. It will deliver high frame rates at 1080p, and will play any game you can think of at 1440p, especially if you enable FSR 2.0. It's well worth enabling it where possible.

When compared to the RTX 3070, it's basically a tie, though in a game like *Metro Exodus Enhanced Edition*, the ray tracing capabilities of the 3070 come to the fore. Which of the two you go for may come down to the games you play. If you favour ray tracing, the 3070 remains a strong option, particularly as its pricing continues to fall. And therein lies the problem for the RX 6750 XT: price.

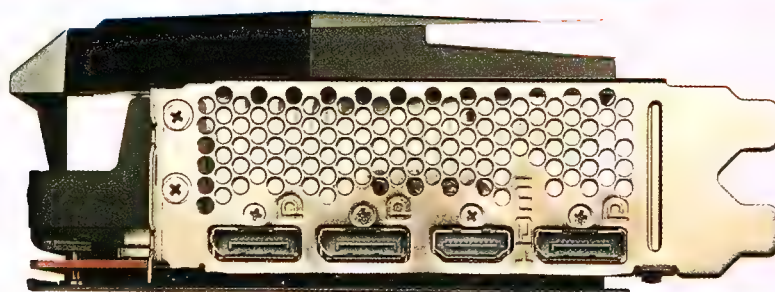
MSI did a superb job with the RX 6750 XT. It's exceptionally well built, quiet and cool as we've come to expect from MSI's Gaming cards. But MSI can only do so much. AMD is simply asking too much for 6750 XT's in the Australian market. At \$1,059, the Gaming X Trio is well over \$100 more than an equivalent 6700 XT. It even costs more than a mid-range RTX 3070. The 6750 XT is a highly capable 1440p card but the same can be said of the year old 6700 XT. As stock levels improve and the card drops to 6700 XT-like pricing, the 6750 XT should become an entirely different proposition. But until it drops under \$1,000, it's a tough sell.

The MSI flavoured RX 6750 XT is an exceptionally cool running and quiet card, but it's not worth the premium over a 6700 XT Gaming X.

Chris Szewczyk

★★★★☆

		Gigabyte Eagle Radeon RX 6500 XT	Sapphire Pulse Radeon RX 6400	Asus Phoenix GeForce GTX 1660
Metro Exodus Enhanced	1920x1080 High Preset - Avg	24.9	20.3	N/A
Far Cry 6	1920x1080 Ultra Preset - Avg	56	48	42
Ghost Recon: Breakpoint	1920x1080 High Preset - Avg	82	60	41
F1 2021	1920x1080 High Preset	114	92	132
3DMark	Time Spy	5,492	4,113	5,956
Temperature	Load @	62	67	77
System Power Consumption	Watts	217	267	231



MSI Radeon RX 6650 XT Gaming X

A faster and cheaper 6600 XT. Sounds good?

■ \$719 | www.msi.com

It wasn't too long ago that \$700 would get you a high end graphics card. While we'd all like to have a 3090 Ti or 6950 XT in our rigs, they are priced at levels most gamers won't even consider buying. Even though the prices of graphics cards have dramatically fallen, building a high-performance gaming PC is still very expensive. At \$719 for the MSI RX 6650 XT Gaming X we have for review, it's still an expensive card, particularly when you compare it to a console. Is it worth the money?

The RX 6600 XT was launched at the end of July 2021. The RX 6650 XT can be thought of as a relatively simple refresh, sharing much in common with its RX 6600 XT predecessor. Both share the Navi 23 GPU. It's an 11.1 billion transistor 237 mm² die with 2048 stream processors. It comes with what appears to be a weak 128-bit memory bus with 8GB of 17.5Gbps GDDR6 memory for 280GB/s of bandwidth and 32MB of Infinity Cache. The RX 6650 carries the same PCIe 8x limitation of the 6600 XT. That's not as big a concern as it is with the 4x link of the RX 6500, but a \$700+ card in 2022 really should run at 16x.

"It's fast, well-featured and secure. But, it suits professionals and prosumers more than undemanding consumers"

■ MSI Radeon RX 6650 XT Gaming X. 2048 Shader Cores; 2,523MHz Game Clock, 2,694MHz Boost Clock; 8GB 17.5Gbps GDDR6 memory, 280GB/s Memory Bandwidth; 3x DisplayPort 1.4a, 1x HDMI 2.1; 1x 8-pin Power Connector, 175W TDP.

When compared to the reference spec RX 6600 XT, the MSI RX 6650 XT Gaming X comes with a higher boost clock of 2,694MHz and 17.5Gbps memory. The RX 6600 XT comes with a 2,589MHz boost clock and 16Gbps memory. AMD says that the card contains some firmware and driver level tweaks. It'll be worth giving AMD's new FSR 2.0 upscaling technology a run if your game supports it.

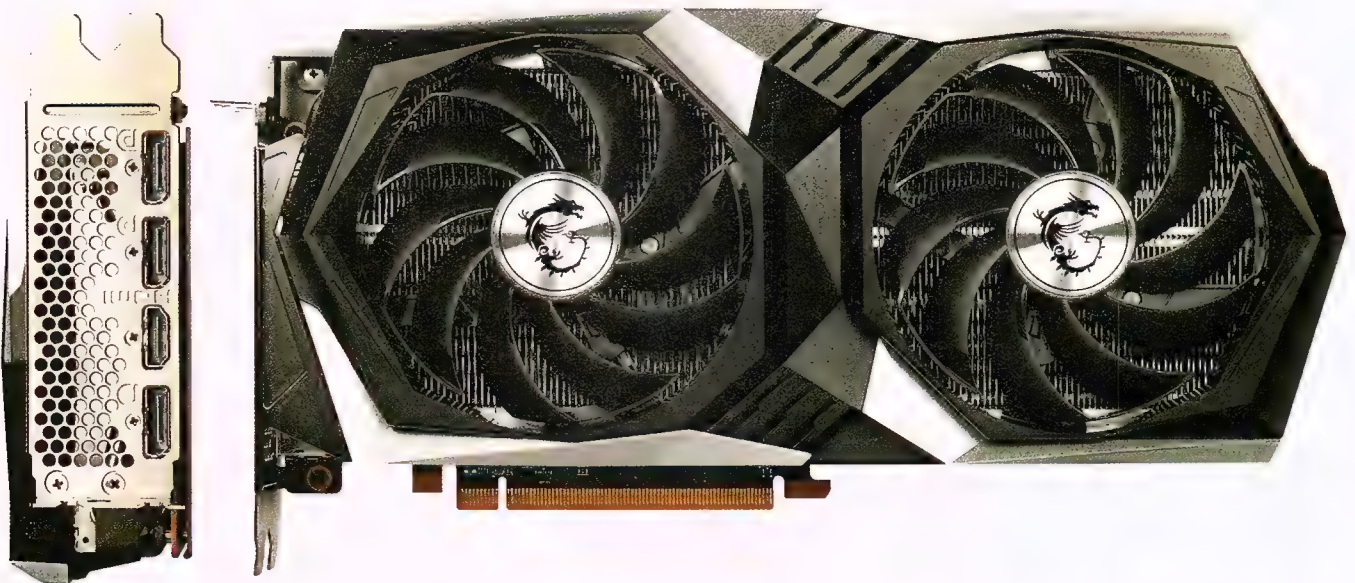
The MSI RX 6650 XT Gaming X features the build quality we've come to expect from MSI's Gaming range. It's equipped with the company's highly efficient Twin Frozr 8 dual fan cooler that's well suited to the 175W TDP of the card. Under a full load, it's barely audible. It's a relatively compact card and it comes with a single HDMI 2.1 and triple DP 1.4a ports. A single 8-pin power connector is sufficient to power the card.

The RX 6650 XT doesn't disrupt the market. It beats the RTX 3060 but trails the RTX 3060 Ti. It's a very good 1080p card and it even nears 60fps in Metro Exodus with ray tracing enabled. It will

play games at 1440p but it might run into some issues in bandwidth sensitive games. The MSI Gaming X is a very quiet card indeed and with a load temperature of 61C, it's a testament to the quality of MSI's cooler design.

The RX 6650 XT is very much an evolution of the 6600 XT. It's what the RX 6600 XT should have been originally. We like that it's cheaper than the 6600 XT, though that's more a result of market dynamics than anything else. Like we talked about in our 6600 XT review, a \$700 card with a 128-bit bus and PCIe 8x limitation just doesn't sit right. The 6650 will deliver excellent performance at 1080p but moving to higher resolutions and details increasingly exposes its bandwidth weakness. The release of FSR 2.0 adds value but if you were eyeing off a cheaper RTX 3060 or more expensive 3060 Ti, the 6650 XT is unlikely to sway your opinion either way.

The MSI RX 6650 XT Gaming X is a quiet and capable 1080p card, but like the RX 6600 XT before it, it feels adequate rather than something truly exciting.
Chris Szewczyk



GRAPHICS CARD

Sapphire Pulse Radeon RX 6400

AMD's entry level graphics card is weak, but there are strengths too.

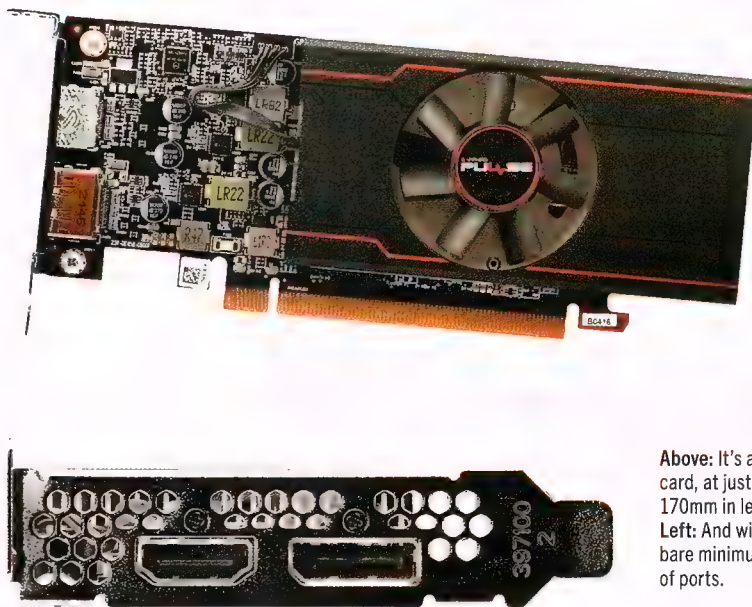
■ \$289 | www.sapphiretech.com

The AMD Radeon RX 6400 is the most affordable RDNA 2 card yet. It's very much an entry level card for general display purposes or casual 1080p gaming, including browser style games or e-sport titles. The similar RX 6500 XT was poorly received, and it'd be easy to bash the RX 6400, but there's still a market for cards like these. It exists to do a job in a variety of systems, as long as you don't ask too much of it.

The RX 6400 is an RDNA 2 based card based on the 6nm Navi 24 GPU. It has 768 shaders enabled. Arguably the card's biggest strength is its 53W TDP. This means it doesn't require external power, ensuring compatibility with a wide variety of systems. This compares to the 107W TDP of the 6500 XT, though with half the power budget, the 6400's clock speeds are much lower, with a boost clock of 2,321MHz compared to 2,800MHz or more for the 6500 XT.

The 6400 is hobbled by its 4GB of memory and 64-bit bus. Even at 1080p, some games will run into limitations. However, the real weakness of the card is its PCIe x4 connection. That's not a problem in a PCIe 4.0 system but this is the kind of card that's going to go into systems with PCIe 3.0 slots (as recent as a 10th Gen Intel system). If you're looking to upgrade a PCIe 3.0 system, or more importantly, something like a Sandy Bridge era PCIe 2.0 system, you might want to look at a card like a GTX 1650.

We have Sapphire's Pulse RX 6400 in for review. Its base specs are the same as all RX 6400s. The Pulse is a low-profile card with a single fan. After years of ever increasing TDPs and monster triple slot coolers, seeing a compact and efficient little card like



Above: It's a small card, at just 170mm in length. Left: And with the bare minimum set of ports.

■ Sapphire Pulse Radeon RX 6400; 768 Shader Units; 1,923MHz Base Clock, 2,321MHz Boost Clock; 4GB GDDR6 16Gbps memory, 128GB/s Memory Bandwidth; 1x DisplayPort 1.4, 1x HDMI 2.1; 53W TDP.

this is refreshing.

The 6400 doesn't impress in games, but that's not unexpected. It can offer decent performance in older or less demanding games. Forget about *Metro Exodus* at 4K with ray tracing, but if you play a spot of *DOTA 2* or *Fortnite*, you'll get reasonable 1080p performance. If you're after a genuine gaming card, then you might want to look at an older card like an RX 580, while stretching your budget to something like a GTX 1660 will deliver much better gaming performance.

The 6400's gaming performance isn't expected to be stellar, but what about its media capabilities? Sadly, they aren't stellar either. Its dual display limitation means it isn't suitable for triple screen workstation use and its lack of AV1 decode support will count against it, particularly as it gains traction with content providers including YouTube and Netflix.

At \$289 the RX 6400 is the first genuinely affordable GPU release we've had in a long time. It could have been an impressive little card, if it included at least PCIe 8x support, triple display capability and AV1 decode support. Without those features it's a mediocre card. Sure, if you need a GPU for display support that doesn't require external power, it will do the job nicely, but there are other competitive options around this price. AMD missed a trick here.

The RX 6400 could have been an affordable and punchy little GPU, but its compromises are too great to truly recommend it.

Chris Szewczyk

★★★★☆

		Gigabyte Eagle Radeon RX 6500 XT	Sapphire Pulse Radeon RX 6400	Asus Phoenix GeForce GTX 1660
Metro Exodus Enhanced	1920x1080 High Preset - Avg	24.2	20.3	N/A
Far Cry 6	1920x1080 Ultra Preset - Avg	56	48	13
Ghost Recon: Breakpoint	1920x1080 High Preset - Avg	82	60	41
FT 2021	1920x1080 High Preset	114	92	132
3DMark	Time Spy	5,492	4,113	5956
Temperature	Load @	62	67	77
System Power Consumption	Watts	217	167	231

COOLING

DeepCool LS720 360mm

A premium 360mm AIO at 240mm prices.

■ \$189 | www.deepcool.com



The importance of capable cooling can easily be overlooked. If a modern processor gets too hot, it will undervolt and downclock, costing you performance. But you don't need to spend \$400 or more on a cooler with an LCD screen if you just want your cooler to, well, cool. An AIO like the DeepCool LS720 aims to offer a blend of ARGB good looks, quality component design choices and an affordable price. Does it hit the cooling sweetspot?

Ostensibly, the DeepCool LS720 is an atypical 360mm liquid cooler, but it's important to look a little deeper to see how it differentiates itself from competing units. Rather than rebrand an Asetek unit as many manufacturers do,

DeepCool designs its own pump. It runs between 2,700 and 3,400 RPM give or take, while promising a noise level of just 19 dB(A). That's genuinely whisper quiet and we simply couldn't hear it above the sounds of our test system's fans.

The pump itself is referred to by DeepCool as a 4th generation design. It's important to pay attention to the mounting as the unit is designed with specific orientations in mind. DeepCool says this can reduce the CPU temperature nearly four degrees in the case of a 280W

"The DeepCool LS720 isn't the cheapest 360mm AIO you'll come across, but it's not far from it."

■ DeepCool LS720 360mm AIO liquid CPU cooler; 410mm Tubes; AMD AM5, AM4, TR(X)4, Intel LGA 1700, 1200, 115x, 2066, 2011(-3) compatible; 3x 120mm fluid dynamic bearing PWM fans; max 32.9 dB(A) Noise Level; five year warranty.

12900K. The head is topped by an infinity mirror. DeepCool chose to incorporate a 42mm x 42mm plastic cover that allows you to attach a customised sticker. It's an interesting way to customise the look of your system, while saving \$200 or more over the cost of an LCD equipped AIO.

The LS720 includes three ARGB FC120

fans with fluid dynamic bearings. They cost nearly \$30 each on their own and are a clear strength of the LS720. They're optimised for high static pressure and they run up to 2,250 RPM. They include a custom daisy chaining

cable. It's a wonderfully simple idea. The cable reduces clutter by carrying power and RGB signalling along one cable, and it removes the need for a hub, letting you connect three fans to single motherboard fan and ARGB headers. Well done!

The baseplate is large and has a smooth finish. We tested it with our AMD 5800X inside an airflow constrained Razer Tomahawk ATX case and found it was able to match a much more expensive NZXT Kraken Z73. Only the TT Ultra 360 outperformed it, but that may come down

to its very impressive Toughfans. The fact that the DeepCool is nipping at the heels of a cooler that costs twice its price is a strong win for the DeepCool LS720.

At around \$189, the DeepCool LS720 isn't the cheapest 360mm AIO you'll come across, but it's not far from it. Those that are cheaper are mostly older generation models that lack LGA 1700 support. Some similar coolers cost a lot more. Coolers such as the NZXT X73 and Corsair iCUE H150i are around \$80 more. That's a nice feather in DeepCool's cap.

The LS720 is a fantastic and affordable 360mm option. At \$189 it's one of the cheaper ARGB coolers on the market, but DeepCool hasn't skimped on the quality of its components. The pump is quiet and effective, the fans are highly capable and we really love the simplicity of the integrated cables. It costs about the same as some 240mm ARGB coolers. As long as your case can hold a 360mm, we know which one we'd choose!

The DeepCool LS720 is a fantastic and affordable 360mm AIO that's able to hold its own against coolers costing a whole lot more.

Chris Szewczyk

★★★★★

WI-FI ROUTER

TP-Link Deco X73

New connectivity options and Wi-Fi 6 make for a compelling router.

■ \$399 | www.tp-link.com.au



Aimed at higher end home users, the TP-Link Deco X73-DSL router supports the latest Wi-Fi 6 spec, has a VDSL modem, and sports two FXS VoIP ports. Importantly, the X73-DSL is fully backwards compatible with other TP-Link Deco products, so can easily be added into an existing mesh network. The X73-DSL sports AX5400 spec Wi-Fi, which gives up to a huge 4,804Mbps of bandwidth on the 5GHz band, and 574 Mbps on 2.4 GHz. The VDSL modem supports 35b supervectoring, for speeds up to 350Mbps, but can also handle ADSL2+ and WAN connections. You also get four Gigabit WAN/LAN ports, and a USB 3.0 connection which can be used to connect a 4G modem for extra connectivity or add storage to the network.

The dual FXS VoIP ports are a key feature for the X73-DSL, and allow the connection of two compatible landline phones. Functionality includes options such as conference calls, logs, call blocking and forwarding, and X73 has a built-in answering machine with 250+ minutes of voicemail recording. The X73 is most easily set up and controlled via the excellent TP-Link Deco app, and has excellent security features, parental controls, quality of service options,

■ Wi-Fi: 802.11ax5400 WiFi 6; LAN: 4x Gigabit WAN/LAN; Modem: ADSL2+/VDSL2; VoIP: 2x FXS ports; Management: Deco App; Warranty: 3 years; Dimensions: 130 x 123 x 210.5mm.

diagnostics, and can even provide network statistic reports. The router is also backed by a three year warranty, has 24/7 technical support, and plenty of how-to videos and guides online.

The X73-DSL can provide Wi-Fi coverage for up to 270 square meters, but you will get even better results using it as the core router in a larger mesh network. Exactly how much of the 5,400 Mbps of bandwidth can be used at once depends on your specific hardware, but we had no trouble transferring data from a NAS to a laptop at near Gigabit speeds. At a 10 meter range through multiple walls we could still achieve 88 Mbps, which could be more than tripled by adding in a mesh node.

We also added the X73 into our existing Deco mesh network, and relegated one of our existing nodes to a more distant location. The process was fast and completely seamless, and with the nodes automatically reconfiguring to the new setup.

We also reset everything to the factory setting and did a fresh setup

using the Deco app, and didn't experience any problems at all.

One of our favourite new features from the X73 is smart home integration. It's mostly aimed at TP-Link products, but is compatible with other smart home brands such as Philips Hue. The Deco app allows actions and triggers, such as turning lights on and off when a specific device joins or leaves the network. The features show great promise, but for now we found some third party hardware hard to connect, and there is no option to link it to Google Home – only Amazon Alexa is supported.

Overall the Deco X73 has a well rounded set of features, but those who don't need the higher end Wi-Fi bandwidth, or VoIP, might be better off looking at Deco models such as the X20.

Great features for those who need high end Wi-Fi, VDSL connection, VoIP, or just want to build out a reliable, high performance mesh network.

Lindsay Handmer

★★★★★

ROUTER

Synology RT6600ax Wi-Fi 6 router

Synology's new router is unlike any other and could change the market. But, should you buy it?

■ \$599 | www.synology.com



Synology routers are not well known in Australia, but the company is making a big push with its first Wi-Fi 6 unit, the RT6600ax. At first glance it may look rather uninspiring, but it doesn't take long to realise this is simply its Clark Kent disguise.

Those familiar with Synology's NAS boxes will know that operating systems are very well featured (with multiple package downloads), frequently-updated, bomb-proof reliable, highly secure and offer a superb user experience – at least for experienced techies. The RT6600ax uses the latest iteration of Synology Router Manager (SRM 1.3) which functions like the DSM NAS OS, replete with desktop and apps – that's a huge step up from the usual router firmware. It's best accessed through a desktop browser window though a fully-featured phone app is supplied. It's designed to be the perfect, secure choice for smart homes, home offices and SMBs and it didn't take us long to see why.

Initial set-up (via browser or app) is simple and we were quickly up and running. The powerful features mean that we preferred to use the browser-based OS to utilise the main features. As with the

■ Speed: AX 6,600Mbps | Connectivity: 3 x Gigabit Ethernet WAN/LAN, 1 x 2.5Gbps LAN, 1 x Gigabit 2.5Gbps WAN/LAN, 1 x USB-A 3.1 Gen 1 | Features: SRM OS 1.3, multi-SSID & network segmentation; enhanced QoS, Firewall, VPN, VLAN, mesh and Family controls.

NAS boxes, everything is simple to access, but some applications are much simpler to configure than others.

Unique, features include the ability to operate multiple, different Wi-Fi network SSIDs, with different policies including QoS and firewall rules for different use-cases. These can be completely

isolated from one another or linked if, say, a printer needs to be shared. Extensive firewall rules can enable one-way only traffic: for instance if your NAS is running surveillance software it can see a one-way feed of an IP camera, but if the camera is

compromised, it can't be used to attack the network.

There are considerable VPN abilities too. Synology made licences free at the start of the pandemic and they can be used to manage all your remote workers' connections to an office network. Meanwhile, the Safe Access package provides powerful parental (and employee) access controls. There's a 2.5 Gigabit WLAN/LAN port which can also be used to add mesh nodes to a network. The tri-band

technology means a 5GHz network can be used as dedicated backhaul to create an expandable, high-performance mega-mesh network with a partner device. Everything is slick and easy to access.

We recently moved house which means new tests. We used the excellent Netgear Orbi RBR850 to provide a performance baseline by downloading large video files from a NAS in the middle of a single-storey Sydney bungalow up close, two rooms away and 25m away at the bottom of the garden. The Netgear scored 710.8, 550 and 30.5Mbps respectively. The Synology scored 736, 392 and 71.6Mbps. (It was only beaten in the second test because the Orbi had mega-mesh partner-node located there).

Ultimately, it's fast, well-featured and secure. But, it suits professionals and prosumers more than undemanding consumers and so we expected an exorbitant price. However, at \$599 it's downright cheap! Consequently, it's not just perfect for SMBs and smart homes, it's changed the whole market.

The RT6600ax is not just fast and laden with unique features, it's a fraction of the price of rivals: revolutionary.

Nick Ross

★★★★★

"It's fast, well-featured and secure. It's not just perfect for SMBs and smart homes, it's changed the whole market."



ERGONOMIC MOUSE

LOGITECH LIFT

The vertical mouse for small mitts.

■ \$129.95 | www.logitech.com/en-au

Vertical mice have developed to keep repetitive strain injuries (RSI) in check, but when the mouse doesn't fit your hand, even the best ergonomics aren't going to help. Enter the Logitech Lift.

It's a smaller, more charming version of Logitech's Vertical MX mouse that's designed to fit small hands like a glove. It's remarkably comfortable and the quiet, tactile switches and scroll wheel enhance the experience. A 57° twist to the vertical 'sail' of the Lift and its ribbed rubber palm rest help maintain posture, reduce strain on the wrist and make the mouse feel secure in the hand.

The Lift requires a single AA battery that, Logitech promises, will last a whopping 24 months (we haven't used the mouse long enough to verify that!). However, there are no indications from the manufacturer on what the precise conditions for such a long battery life are. In our testing, it took the Lift about

eight work days to drop one percent of charge, which is in line with Logitech's promise. As impressive as that sounds, we'd have preferred the USB-C charging port that the bigger Vertical MX possesses.

The Lift inherits the 'easy-switch' functionality found on most other premium Logitech mice, allowing you to connect up to three devices simultaneously. Bluetooth connectivity is seamless (even for macOS), but a USB receiver is also provided.

We found absolutely no issues with the Lift's performance, although this will vary depending on individual needs. You can use the Logitech Options app to make some adjustments, like saving two DPI presets, but don't expect high-speed tracking resolution comparable to gaming mice. That said, the Lift is more than capable of handling everyday workflows with ease... and look gorgeous while doing it.

"It's remarkably comfortable and the quiet, tactile switches and scroll wheel enhance the experience."

The Logitech Lift is an attractive mouse with the everyday performance and ergonomics to match... provided you possess small hands.

Sharmishta Sarkar

★★★★★



MEMORY

G.SKILL TRIDENT Z5 RGB DDR5-5600 C28 2X16GB

The lowest latency DDR5 memory yet.

■ \$TBA | www.gskill.com

One of the weaknesses of DDR5 memory is its relatively high latency compared to DDR4. In most cases, a good set of either type will serve you well, but lower latency can give you an extra little boost, particularly in games that are latency sensitive. With that in mind, G.Skill has released what we believe to be the first sub CL30 DDR5 kit. At DDR5-5600 28-34-34-89, it's a high-quality kit designed for users specifically hunting for low latency.

The G.Skill Trident Z RGB DDR5-5600 CL28 memory kit comes with SK Hynix IC's which are common to the highest performing DDR5 memory kits. The G.Skill kit looks fantastic. It's sleek design and RGB implementation features a slightly subtler diffused light that won't burn out your retinas.

Looks aside, what really matters is how this kit performs compared to the many 6,000MHz+ kits that are now widely available. The G.Skill kit is able to match a 6,400MHz C40 kit in *Ghost Recon: Breakpoint* and *Metro Exodus: Enhanced*, while in other apps the extra bandwidth is more beneficial. We'd recommend the G.Skill kit for gamers.

At the time of writing the G.Skill kit was yet to have its price finalised, but it's likely to be similar to other high performance SK Hynix kits at around \$700. They are all highly tweakable so in the end, the differences between them won't be all that great. The 5600 C28 is a good option for a user looking for an XMP set and forget kind of kit. Though at this price it's only suitable for those who have a high end system to match it with.

This kit sets a new standard for low latency, but its value will only be appreciated by a small subset of the market.

Chris Szewczyk

★★★★★

	G.Skill Trident Z5 RGB DDR5-5600 2x16GB	Teamgroup Delta RGB DDR5-6400 2x16GB
Handbrake 1.4.2 - Video conversion 4K to 1080p FPS	83.3	83.5
7Zip 21.03 - File Compression - Billion Instructions per second	140.32	143.17
Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	242	242
Metro: Exodus Enhanced Edition - 1080p, Low, Avg FPS	133.6	133.5

GAMING KEYBOARD

Razer Huntsman Mini Analog

A small but mighty keyboard.

■ \$TBA | razer.com

What do controllers have over the reliable old keyboard-and-mouse combo? How can they hope to match the unerring precision of the mouse? How can they keep up with less than 20 buttons to press? Variable input force has long been an advantage in all sorts of games, from racing titles to shooters and fighting games. The ability to move your avatar or turn your vehicle slowly, delicately, with a single sustained input rather than constant anxious key-tapping, can be an oft-underrated boon. Fortunately, keyboards are catching up.

The Huntsman Mini Analog isn't Razer's first foray into using analog-input key switches, nor its first attempt at a 60 percent keyboard. The original Huntsman Mini was a fine example of a compact gaming keyboard, while the Huntsman V2 Analog offered Razer's flashy switches in a full-scale layout. What we have here is a mashup of those two keyboards, the best of both worlds.

It should go without saying that you need to be comfortable with the 60 percent

"It should go without saying that you need to be comfortable with the 60 percent layout to get the most out of this keyboard"

layout to get the most out of this keyboard. There's no numpad, no dedicated function, or media keys, and everything is squeezed together for the smallest possible overall size. It's impressively lightweight but sturdy, ideal for tossing in a backpack for LAN parties or maintaining a minimalist gaming space. The detachable USB-C to USB-A cable is braided for improved durability.

The keycaps are doubleshot PBT with a nice textured feel to them and will never lose their labelling through heavy use. More than half the keys have secondary functions printed on their front-facing sides, to make executing additional commands more intuitive. Beneath those keycaps lurk Razer's proprietary Analog Optical switches, which promise more precise movement control, superior lifespan, and adjustable actuation levels.

So, how well do they work in practice? The variable analogue input is fantastic; moving and steering in games feels amazing, with a gentle push providing slight movements while a firm press sees

you fully commit to a direction. The adjustable actuation is great too; setting the actuation point high gives you ultra-twitchy responsiveness while dialling it down makes for a more comfortable typing experience.

One lauded feature of the Razer Analog Optical switches is the option for 'dual-step actuation', which allows you to map two different commands to one button. The first command triggers upon initial actuation, with the second activating when you further depress the key. Razer suggests this could have a plethora of uses for two-action combos in games, and it does to a certain extent. We tried using it for equipping and then throwing a frag grenade in *Apex Legends*, which worked reasonably well in a pinch, but actually trying to use those two commands separately is tricky. It strikes us as a niche feature that many players aren't likely to use. Overall though, this is a top-notch compact keyboard for the serious gamer.

Excellent build quality with precise optical analogue switches and lots of customisation options.

Christian Guyton

★★★★★



Windows 7, 8.1, 10 or 11 | www.faststone.org**FASTSTONE IMAGE VIEWER 7.6**

FastStone Image Viewer is one of the most popular free programs for browsing photos stored on your computer.

FastStone Image Viewer is one of the most popular free programs for browsing photos stored on your computer. This latest version is its best yet, adding several welcome features and making the program speedier to use.

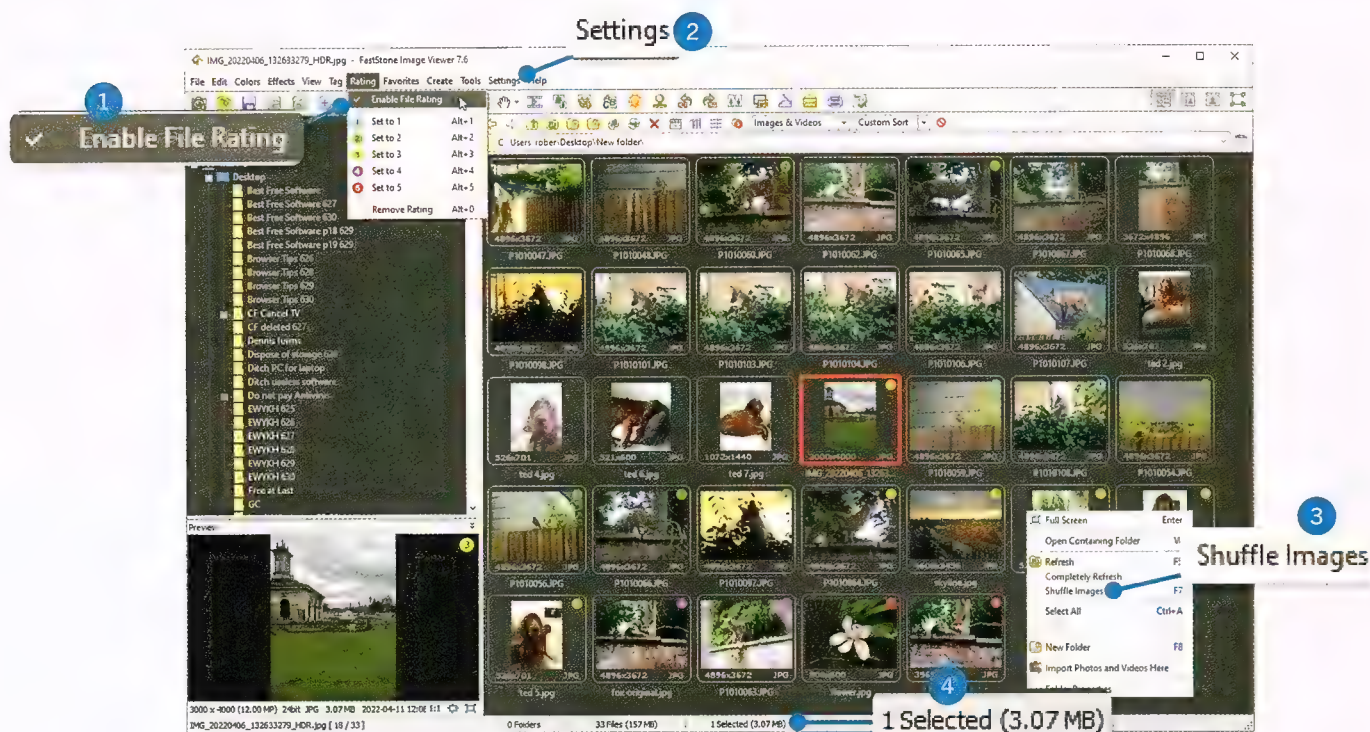
You'll notice an improvement in performance from the moment you launch FastStone Image Viewer 7.6, because it now loads more quickly and displays its 'tree' of folders instantly, as well as their contents when clicked. Select an image, and FastStone helpfully shows its size in the status bar at the bottom of the program window, as well as in the preview pane in the bottom-left corner. If you find the default interface too bright, you can switch to the dark or grey theme – both of which have

been enhanced in this update – by clicking the Settings menu and choosing Theme.

The most notable new feature is a ratings system that lets you rate your pictures by selecting a colour-coded number, from one to five. This is very useful for providing at-a-glance information about the quality of your photos, especially when you've taken multiple shots of the same subject. It's disabled by default, but you can turn it on by clicking the Rating menu and selecting Enable File Rating. Hover your cursor over an image and click the circle that appears in its top-right corner to apply your rating. You can then sort your pictures in order of their ratings by choosing that option in the Thumbnail Order menu.

Another handy addition is the ability to create thumbnails for new images without needing to open the folder they're in. Click the Settings menu and choose 'Pre-Scan Folders into Thumbnail Database' to enable this. We also like that you can see where a photo was taken on Google Maps – provided its metadata includes GPS coordinates – by pressing Ctrl-Shift-M, and on Google Earth by pressing Ctrl-Alt-M.

"The most notable new feature is a ratings system that lets you rate your pictures by selecting a colour-coded number, from one to five"

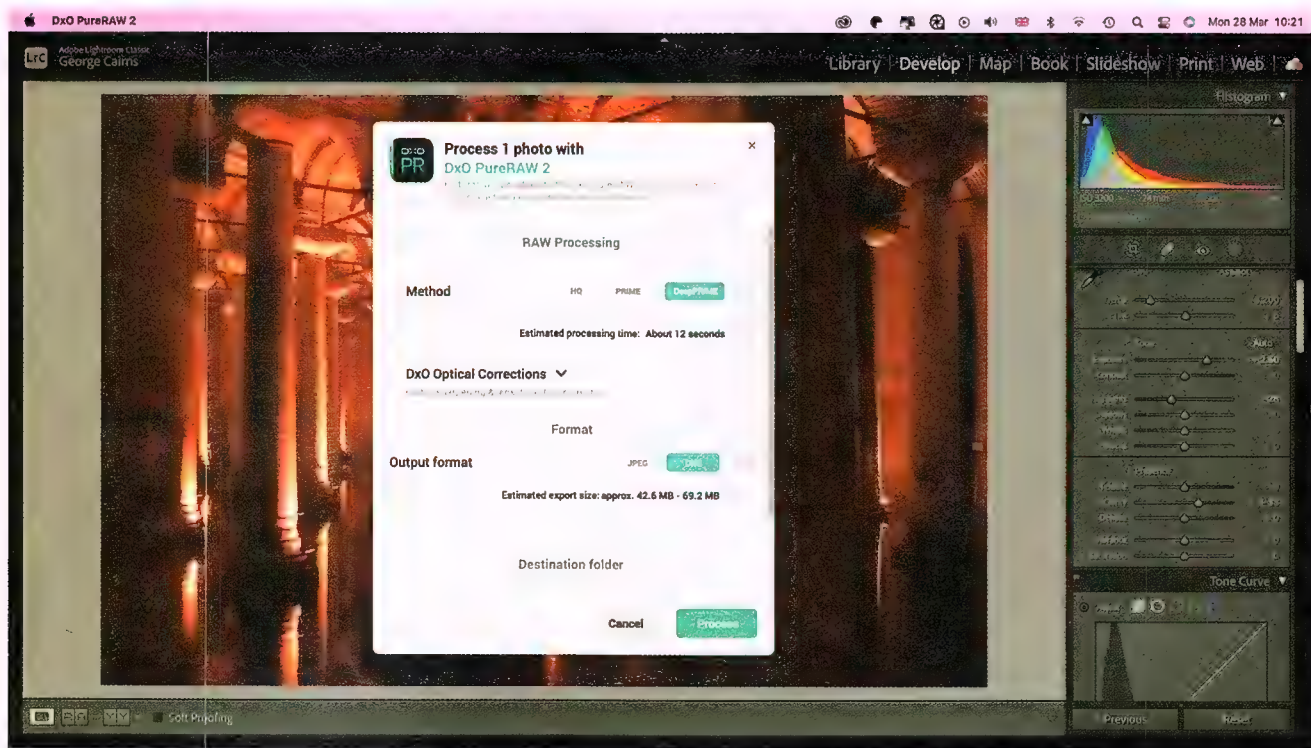


1 FastStone Image Viewer now lets you rate your pictures, so you can grade their quality from one to five. To activate this feature, click the Rating menu and select Enable File Rating. Rate an image by clicking its top-right corner.

2 You can protect your eyes when using the program at night by switching to one of its dark themes. Click the Settings menu then choose an option from the Theme menu. In our screenshot, we've applied the Grey theme.

3 The new Rating system lets you sort your pictures by quality as well as other new criteria such as date taken. Alternatively, you can let FastStone decide the order of your photos by right-clicking an empty area and choosing Shuffle Images.

4 Usefully, the program now displays the size of a selected image in the status bar along the bottom of the window. You can see further information, such as the image's date, file type and dimensions, at the bottom of the preview pane.



MacOS 10.15.7 or later | US\$129 | dxo.com

DXO PURERAW 2

Polish a Raw picture's pixels to perfection.

Above: PureRAW 2 runs in Lightroom Classic as a plug-in, streamlining your workflow.

On the left is a soft and noisy look from Lightroom Classic. On the right, a sharper clearer s hot from DxO PureRAW 2.



DxO PureRAW 2 uses DeepPRIME machine learning to counteract a range of artefacts that can spoil a Raw format photo. It will reduce noise, correct optical lens distortion and colour fringing, counteract vignetted edges and sharpen details. It does this more effectively than the native tools in apps such as Adobe Lightroom Classic. And once PureRAW 2 has preprocessed a shot, you can use Lightroom Classic or Photoshop's Camera Raw tools to process other picture properties such as colour, composition and tone.

The app enables you to revisit old Raw files in apps such as Lightroom Classic. For example,

some of your old Raw shots may have been rejected by a stock photography site's inspectors for suffering from too much ISO noise. Now thanks to PureRAW 2's machine learning powers you can smooth out unwanted noise while preserving (and sharpening) important info.

Prior to this latest version, you needed to export your Raw files into the standalone PureRAW application, preprocess the pixels to reveal more detail, reduce lens distortion and denoise them. You then had to export a DNG version of the cleaned-up file back into a digital darkroom app such as Lightroom Classic for further tweaks. With PureRAW 2, you can access the app directly from within Lightroom Classic as a plug-in. The plug-in is implemented well and any previous noise reduction or lens corrections made with Lightroom Classic's native tools are ignored in favour of PureRAW 2's more effective results. The downside is that it can take a minute or so before the PureRAW 2 processed version appears in Lightroom Classic.

The streamlined workflow lets you browse shots in Lightroom Classic, apply the AI-assisted tools

to clean them up and then process them to perfection using Lightroom Classic's wide range of digital darkroom tools. Sadly, you can't enjoy the app directly from within Photoshop Camera Raw as that workspace is already a plug-in to Photoshop. However, you can still process a file in the standalone version of PureRAW 2 and then open it in the Photoshop Camera Raw editor.

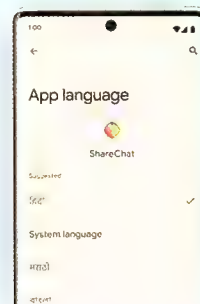
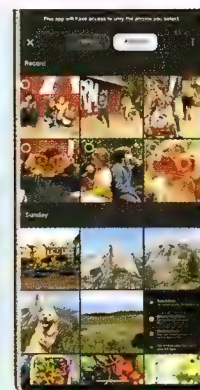
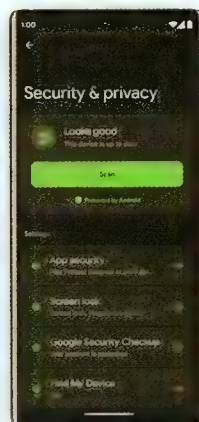
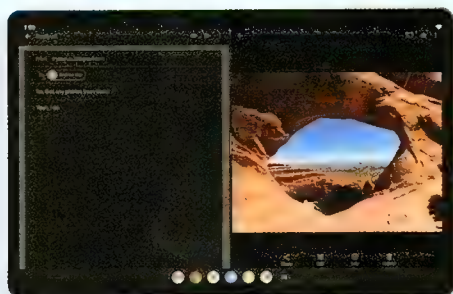
If you shoot Raw files on iPhone and organise them in Photos, give PureRAW 2 a miss. It doesn't support native DNG files created by the iPhone's Camera app. However If you're a traditional DSLR photographer who has shot in Raw format for years, it's worth investing in, especially if your shots have been organised into a Lightroom Classic catalogue.

PureRAW 2 does do an amazing job of revealing detail while reducing artefacts, making it a valuable addition to Lightroom Classic's toolset and a valuable stand-alone resource.

Makes your DSLR's old camera Raw files look better than ever before thanks to AI assistance.

George Cairns

★★★★☆



Android | Free

ANDROID 13 BETA 2 ARRIVES WITH A NEW PHOTO PICKER, BETTER THEMING, AND MORE

Beta 2 adds even more new features.

Google had plenty to share during its I/O 2022 Keynote, and that of course includes the world of Android. Unlike last year's Android 12 announcement, there aren't nearly as many drastic additions coming to Android 13. However, there are quite a few impressive changes that aim to improve your experience across the best Android phones and tablets.

As we expected, Google took some time to focus on security and privacy settings. With Android 13 Beta 2, we're getting an all-new photo picker, providing more controls over the files that can be accessed by different apps. There are also new categories for "Files and media," "Photos & videos," and "Music & audio." This photo picker allows you to select specific files to share with different apps, as opposed to an "all-or-nothing" approach.

With the current version of Android 13, Google noted how you will need to regularly provide notification access to different apps. This is being expanded in Beta 2, with location permission requirements being reduced for various apps. Keeping with the security trend, your phone will automatically clear the clipboard history after a "short period,"

preventing other apps from seeing information that it doesn't need.

Android 13 Beta 2 also provides a slightly-tweaked interface for the Security & privacy section on your Android phone. The goal of this is to provide better colour-coding for areas that need some attention, along with providing steps to keep your phone and information more secure.

When the first Android 13 beta was released, we noticed that changes to the Material You colour palette had been updated with more options. As it turns out, this is getting expanded even further, as those various colour accents will appear in more Google apps.

This is getting turned up a notch, as the "Themed icons" option will now apply to any third-party apps that support the Material You theming engine. The end goal is to provide an even more cohesive and unique-to-you look and feel across your entire device. Google has also confirmed the changes coming to media controls, as it will also apply the Material You theme to go along with the awesome squiggly playback line.

Last, but certainly not least, Google is combining the tablet-focused features of Android 12L and expanding on them with Android

13. There's an all-new multitasking interface coming to compatible tablets, made possible by Google's new taskbar. Once available, you'll be able to drag and drop apps from the App Library onto your screen with ease.

Android 13 is also bringing improved palm rejection when using tablets with a stylus. This is something that we've seen Samsung and Lenovo attempt to implement, but it's a welcome addition coming to Google's version of the OS.

In a rather surprising announcement, "more than 20 Google apps" are being updated. These apps will be able to take better advantage of the screen real estate made available.

Google also confirmed it is working with other companies, such as Zoom, Facebook, and TikTok, to provide "revamped" interfaces for tablets.

While that may seem like a lot of changes, there are even more to come as Google confirmed support for Spatial Audio and other features.

"As we expected, Google took some time to focus on security and privacy settings."

OPENMANDRIVA LX 4.3

In what seems to have become a trend, just when he gives up hope, a project pleasantly surprises Mayank Sharma with a new release.

Released after almost a year of development, the OpenMandriva developers didn't plan to have a 4.3 release, but decided to create it to push the changes made behind the scenes without keeping users waiting a few more months for version 5.0.

OpenMandriva Lx 4.3 is available as an installable live media. In addition to the generic 64-bit release, there's also a version built specifically for the current generation of AMD processors including Ryzen, ThreadRipper and EPYC. The developers claim this version outperforms the generic 64-bit release by taking advantage of new features in the AMD camp.

This is also the first OpenMandriva release that's available for 64-bit ARM devices. Installable images for popular ones such as the Pinebook Pro, as well as for single-board computers including the Raspberry Pi, are being tested and will be released shortly. The developers also claim that the aarch64 port enables them to target smartphones as well, and there's a beta-quality image for the PinePhone available.

The majority of its interesting changes are behind the scenes. The release continues OpenMandriva's tradition of using the LLVM compiler, as opposed to GCC that's used by most other distros. The developers claim the compiler's link

time optimisation makes the desktop and the programs a lot more responsive. And thanks to the new LLVM Clang 9.0 release, it's now possible to use LLVM Clang to compile the mainline Linux kernel, and the release offers one for users to test.

The release has some interesting changes to the frontend, too. The distro still defaults to using the KDE desktop environment, but PipeWire has now taken over as the default sound server replacing PulseAudio, and the distro's custom utilities get a fresh lick of paint.

The first of these that users will run into is the welcome utility, which introduces the distro and helps users tweak key aspects of their computer. The utility also has a list of tools, both open source and proprietary, to help users flesh their installations.

The welcome app points to another OpenMandriva speciality, the desktop presets utility that leverages KDE's famed malleability to rearrange the desktop furniture and make it resemble the interface of other popular operating systems like Windows, and macOS.

Outside of the welcome screen, you can pull in additional programs using either KDE's Discover tool store or the Dnfdragora frontend to the command-line dnf package manager.

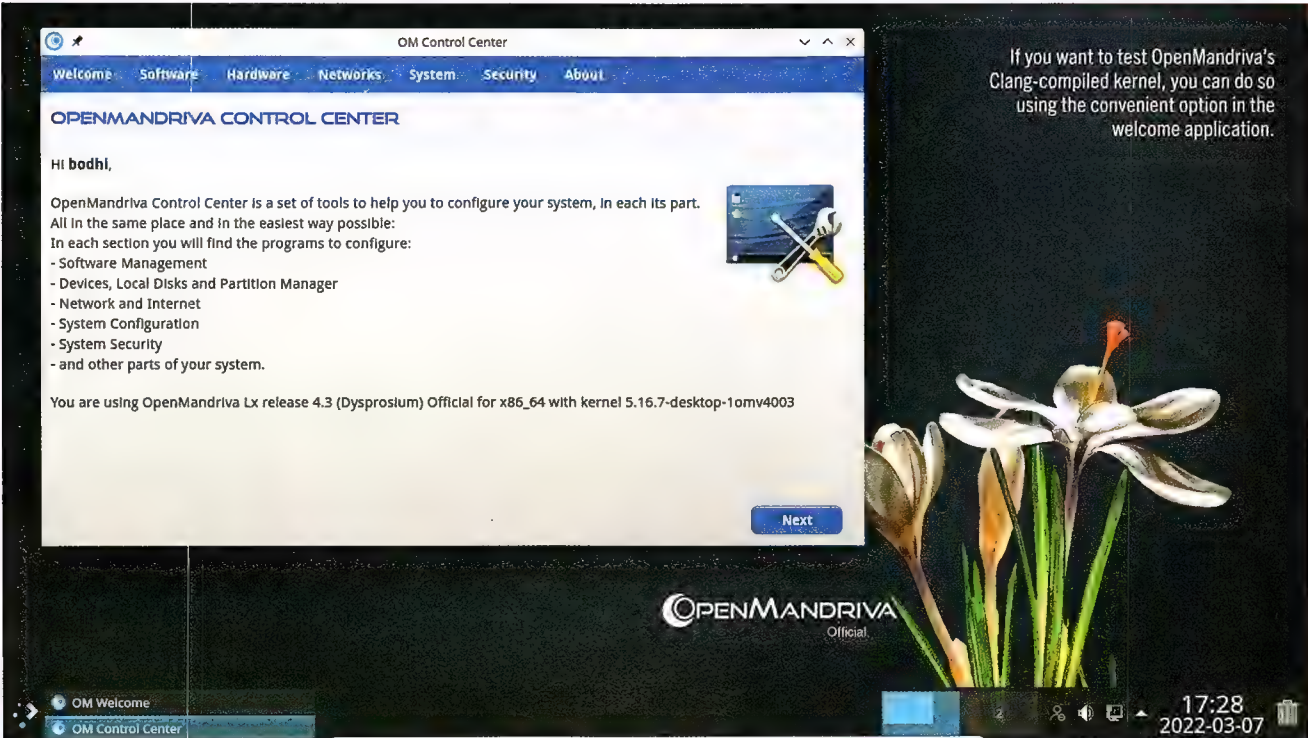
The distro defaults to using the stable

repository it calls Rock, although there's a rolling branch also for users who want to stay on the bleeding edge. You can switch between the repositories using the custom software repository selector tool. While you can easily switch between the two update channels, the developers ask never to mix the repositories from different release versions or update channels.

Of course, the distro's marquee custom tool is the OpenMandriva Control Centre, which is also accessible from the welcome tool. It has a neatly arranged menu that houses a plethora of tools and utilities to help users configure and personalise their installations.

If you're a KDE fan, OpenMandriva is one of the classiest renditions of the desktop. Not only does it ship the latest edition of the desktop, its custom tools make tweaking, tailoring and administering the installation a mouse-driven activity. The distro focuses on the desktop user, and is optimised, from the kernel upwards, to deliver a streamlined user experience.

A well-put together desktop distro that works as advertised and even offers specialised builds for users with AMD chips.
Mayank Sharma
★★★★☆





FEATURE

Screen tech in 2022

OLED monitors are here at last. But as Jeremy Laird reveals, you can expect plenty more panel tech in 2022.

Nailing down the exact launch date of the very first colour LCD monitor for the PC isn't easy. But one of the earliest was certainly the NANA0 F-1020 from Eizo. Launched way back in 1993, the F-1020 spanned a mighty 10.4 inches and rocked no fewer than 640x480 pixels. Count 'em!

As it happens, by Eizo's own estimations, it was a sales flop. Yet here we are nearly 30 years later drowning in LCD panels. The technology absolutely owns the PC monitor market. But is everything about to change? The arrival of the awesome new Alienware OLED gaming panel (see APC 506 for the review, where it scored a perfect 5/5) certainly suggests so.

At last, per-pixel lighting is actually a

thing for the PC and not just smartphones and TVs. Plus far faster response, not to mention much better pixel response, and... we're getting ahead of ourselves. The reality is that OLED isn't going to assimilate the monitor market overnight. What's more, LCD technology still has plenty more to give.

So, yes, the story of the PC monitor in 2022 is likely to be one of a technological turning point, the beginning of the end for LCD panels. But even if that is the overarching narrative, there are plenty of other subplots to enjoy, including 8K awesomeness, ridiculous refresh rates, and a whole lot more besides.

Let's make one thing perfectly clear. LCD is a terrible technology for a full-colour display. Truly, it could hardly be less suitable. The basics involve shining light through a small aperture containing liquid crystals, the latter changing orientation in response to an electrical current.

That enables light to either pass through or be blocked. Put three of these tiny, independently controlled "subpixel" windows together – one red, one green, and one blue respectively – and you have a system that, in theory, can render any colour. The critical phrase here is "in theory". Because in practice, LCD has several fundamental issues.

For starters, the fact that liquid crystals have to move at all immediately introduces latency. It takes time for the position or state of the crystals to move in response to a change in current. That process may be quick, but it is never going to be instant. Similarly, while the amount of light passing through each subpixel is limited according to the crystals' orientation, it is never fully blocked. Some light always leaks through.

Making matters worse, the amount of visible light that escapes varies depending on your vantage point. Typically, maximum light blockage takes place perfectly perpendicular to the panel surface. But from any given viewing point, that will apply to only a small portion of the display. As you look

around the display, you are viewing each point of the panel from a slightly different angle. So you get both apparent variances across the display from a fixed position, and changes in brightness and colour if you move position.

To cut a long story short, LCD monitors have fundamental issues with response, contrast, colour control, and viewing angles, which is pretty damning of the technology. In that context, what's most remarkable is just how good LCD tech has become since that seemingly inauspicious NANAOF-1020 monitor.

Today, pixel response is measured in fractions of a millisecond, the viewing angles of the best IPS monitors are good enough to be a non-issue in many scenarios, colour fidelity is measured in billions of hues, and the introduction of full-array backlighting is finally solving the contrast conundrum.

Indeed, it is actually possible to almost entirely fix that final issue of light control and contrast. The trick is to put two LCD panels together in a sandwich, both of the same headline resolution. You can then use the rear panel to act as a per-pixel dimming array, allowing most of the light to be blocked before it reaches the primary panel and, in turn, dramatically improving black levels, contrast, and HDR performance. The catch? That's an incredibly complex setup that introduces a whole new layer of display modulation. It requires



Back in 1993, the Eizo F-1020 was one of the first flat panel monitors for the PC.

algorithms to control the dimming panel, which can cause image problems of their own.

Delayed response

None of that, of course, addresses the other major failing of LCD technology – response. Impressive quoted response times claimed by the latest gaming panels are, in truth, fairly fictional. The standard measure of pixel response used by most monitor makers and referred to as 'grey-to-grey' ignores the first 10 percent of the transition from one colour to another and also the last 10 percent. Only the middle 80 percent is measured, which just so happens to be the bit that occurs the fastest. The full response time can be 10 times or more slower. In other words, the true response time of a 1ms LCD monitor may actually be 10ms.

The good news is that the answer to pretty much all these problems has finally arrived in 2022. Strictly speaking, the Alienware AW3423DW isn't the first PC monitor based on OLED technology. But everything that's come before has either been the equivalent of that early Eizo LCD panel – a glorified beta test at the buyer's expense – or a mega-money monitor aimed at narrow professional applications. The Alienware is the first consumer-ready, minimal compromise, affordable OLED PC monitor.

It's also miles faster, in terms of pixel response, than any LCD

"To cut a long story short, LCD monitors have fundamental issues with response, contrast, colour control, and viewing angles, which is pretty damning of the technology."



The LG UltraFine 32EP950 is a 4K OLED PC monitor, but is only 60Hz.

monitor. It has essentially perfect contrast, thanks to each pixel containing its own independent light source, plus with none of the blooming, and thus incredible low range HDR performance. And its viewing angles are virtually flawless. It is, surely, the best gaming monitor we've ever seen, but that doesn't make it the best all-round monitor you can buy. It isn't even close to being the best option for most productivity tasks. As you'll have seen from our review in APC 506, the AW3423DW isn't perfect.

Some of the ways in which OLED panels aren't perfect will ensure that LCD monitors remain relevant for some time. The first is resolution. At 3,440x1,440 pixels

and under 110dpi, the Alienware AW3423DW has decent pixel density for gaming. Some would argue it's pretty much perfect for a 34-inch ultrawide gaming monitor, just the right balance between visual detail and allowing for high frame rates. More pixels would deliver greater detail but at the cost of zingy frame rates and low input latency.

We wouldn't disagree. But we'd also point out that there's much more to PC usage than gaming. For almost everything else, more pixels is usually a good thing. While high-resolution mainstream OLED monitors will likely come on stream in the next few years, we're not expecting anything affordable in 2022. Of course, right now, you can now get a 4K 27-inch monitor with around 160 pixels per inch for little more than \$400. With that 160dpi, you get crisper fonts and more image detail than a 110dpi panel such as the Alienware OLED.

Of course, by today's standards 27-inches is relatively puny. Which is where one of the big trends of 2022 steps in. This year, 32-inch 4K monitors with high refresh are going to be a thing. Until the latter half of 2021, 4K with high refresh was limited to 27-inches. But this year, the market is going to be flooded with monitors like the Gigabyte M32U. That's a 4K, 32-inch IPS model with 144Hz refresh support.

The M32U can currently be had for around \$950. So, it's actually relatively affordable, which isn't something you can say of most

things in 2022. What's most promising about the Gigabyte M32U and competing monitors like the Asus ROG Swift PG32UQ is that they make for outstanding all-rounders. You get all that 144Hz gaming goodness, plus a fantastic 4K pixel grid for epic productivity, plus nice, sharp fonts.

To put this appealing 32-inch IPS monitor class into context, the only comparable and currently available 32-inch OLED monitor is the LG UltraFine 32EP950, which is limited to 60Hz and costs \$4,000 in America, and isn't even sold in Australia yet. LG has said it plans to release a high-refresh 32-inch 4K OLED model in the future. But there's no date, no price, no nothing. We don't expect anything soon and predict that when it does arrive, it won't be cheap.

Perhaps more promising is similar news from AU Optronics, the Taiwanese manufacturer of LCD and OLED panels used by a wide range of TV and monitor makers. AU doesn't produce actual TVs and monitors, just the panels that go into them. AU tends to price its panels aggressively, allowing monitor makers to hit lower price points than they otherwise would buying panels from some of the other big suppliers, such as LG and Samsung. And AU has plans for a 32-inch, 4K, 144Hz OLED panel. Again, there's no date or further information. So, it seems unlikely that we'll see a high fresh 4K OLED monitor this year. But it's coming.

As it happens, AU also says it is tooling up for something even more

Dead end display: Dell's UltraSharp UP3218K of 2017 is still the only vaguely mainstream 8K monitor... for now.



THE ULTIMATE DISPLAY TECHNOLOGY BUT YOU'LL HAVE TO WAIT FOR IT

It's the flat panel to rule them all, the ultimate display tech – we give you MicroLED. But it's not coming to the PC anytime soon. It's still years away, which is a pity because when it does hit the PC, it's going to be awesome.

Like OLED, MicroLED is a self-emissive technology that offers true per-pixel lighting. So, each individual pixel can be turned off completely. That means essentially infinite contrast and true black tones. The difference is that MicroLED sidesteps organic compounds and so doesn't suffer from burn-in. The latter is a major

issue with OLED displays because of the differential degradation within the RGB subpixels.

In an OLED panel, the blue subpixels wear out faster than the red and green subpixels. That eventually causes permanent colour distortion seen as burn-in. It's a problem that's particularly tricky on the PC due to persistent on-screen elements such as the Windows taskbar, a prime candidate for burn-in.

Of course, the latest OLED panels have numerous mitigating strategies for reducing burn-in. Samsung, which supplies the panel for the new Alienware

OLED gaming monitor, and Alienware's parent company Dell are both confident it won't be an issue to the extent that they provide a three-year warranty covering any burn-in issues.

However, burn-in isn't MicroLED's only advantage. It also supports peak brightness right across the entire panel, whereas OLED can only achieve that in small isolated patches of the screen. An OLED panel with a peak local brightness of, say, 1000 nits can typically only hit around 150 of full-screen brightness.

The consequence is that even

the latest OLED panels struggle with really bright scenes in HDR content, suffering from clipping and loss of detail. OLED is at its best in HDR terms when the screen is mostly dark with a few small and bright objects. MicroLED solves that problem and will be by far the best performing panel tech for HDR content.

So, why isn't MicroLED coming to the PC soon? In a word, money. MicroLED remains very expensive, as in US\$80,000 for the cheapest currently available MicroLED TV. An Australian price has not yet been announced.

spectacular, namely an 8K, 32-inch, 120Hz OLED monitor. Again, don't expect to be buying a monitor based on this panel anytime soon, but it is a thoroughly tantalising prospect. It also brings us neatly to the next big trend for 2022. Yep, 8K.

8K, on the way?

Now, an entirely justified immediate reaction to the notion of 8K would question the point of it. After all, there's virtually no existing 8K content when it comes to movies and TV shows. There's barely any streaming content available in 8K, beyond demo reels. Likewise, although most games can render at 8K, it generates literally four times the load of 4K. And only the most powerful current GPUs can kick out decent frame rates at 4K, let alone 8K. It is true that both AMD and Nvidia's next-gen GPUs, due later this year, are expected to be a huge leap forward in terms of performance. But even if they do deliver the rumoured 2-2.5x boost in performance, that's not enough to offset the huge additional rendering load 8K generates over 4K.

So, 8K isn't about watching movies. It's not about playing games. What it is about, however, is pixel density. It's debatable exactly how many pixels you need per inch before each individual pixel becomes invisible to the human eye and further density becomes redundant. Visual acuity varies from person to person. Much depends on the device being used, viewing distances, and so on. But when it comes to desktop monitors,

and much as it pains us to admit it, Apple probably has it right with its so-called Retina displays.

Those clock in at 200dpi minimum. That's significantly higher than the 160dpi of a 27-inch 4K monitor or indeed the 140dpi of the 32-inch 4K class. When it comes to things like super-crispy font rendering and image detail, however, high DPI really makes a difference. Go to something bigger like a 40-inch 4K display and the result is a chunky 110dpi, the same as that Alienware OLED gaming

panel. 8K also allows you to view 4K content at full resolution with plenty of screen real estate left over for toolbars and timelines.

When it comes to PC monitors, you currently have a choice between a reasonable but perhaps not quite true high-DPI experience from smaller 4K monitors, or a larger display with big, fat pixels. The closest thing to an exception is the Dell U4021QW, a 40-inch ultrawide panel with 5,120x2,160 pixels. But even that is only 138dpi.

The answer is 8K. For an idea of

The Gigabyte M32U delivers 4K and 144Hz in a relatively affordable 32-inch, IPS package.



There are numerous reasons why, but one of the most intractable involves the existing 'pick and place' manufacturing technique for MicroLED panels. It essentially means each MicroLED subpixel is being individually installed on the MicroLED backplane. On a 4K panel, that's no fewer than 24 million MicroLEDs.

It's one reason why existing MicroLED screens are currently made up of multiple panels. That makes broken pixels less of an issue if part of the panel can be replaced. That 'pick and place' method also puts a lower limit on pixel density. Consequently, the smallest 4K MicroLED screen

produced so far is a Samsung 75-inch model.

Looking to the future, the great hope is that inkjet-like printing processes can be used to lay down MicroLED pixels, en masse. If that happens, costs will plummet dramatically. But even taking the most optimistic view of MicroLED manufacturing tech, we're at least five years away from moderately affordable TVs. MicroLED PC monitors with sufficient pixel density to replace LCD technology and cheap enough that normal people can afford them? They're even further out than that. What a pity.



Cheap at US\$80,000: Samsung Wall MicroLED TV is far from mainstream adoption.



Only the latest graphics cards, including the Nvidia GeForce RTX 3080, can do 4K at 120Hz over HDMI.

just what's possible with 8K, try this for size, literally. A 55-inch 8K panel has more or less the same pixel density as a 27-inch 4K monitor. In fact, it is more or less four 27-inch 4K panels joined together. As it happens, you can get a 55-inch 8K TV for about \$2,500 and drive it at 60Hz over HDMI 2.1 provided you have either an Nvidia GeForce 30 Series GPU or one of AMD's Radeon RX 6000 graphics boards. That sounds appealing, right?

The problem is that every 8K TV on the market uses the BGR, or Blue-Green-Red, subpixel structure rather than RGB (Red-Green-Blue), the latter being the standard for PC monitors. That matters because software, including the Windows operating system, leans on the RGB subpixel structure to effectively create a higher addressable resolution in some scenarios, especially font rendering. Microsoft's ClearType font smoothing tech does just that. And it doesn't work correctly by default with the BGR subpixel structure.

Without getting bogged down in detail, it is possible to set Windows ClearType to address BGR subpixels rather than RGB and enable correct rendering. But some applications don't respect ClearType's global settings, including Chrome, so you can end up with a mishmash of correct and incorrectly rendered fonts.

Even though Dell launched the 8K UltraSharp UP3218K way back in 2017, it remains virtually alone in the market as an 8K monitor rather than TV, and runs off DisplayPort 1.2 rather than DisplayPort 1.4 and HDMI 2.1. So, you have to connect via dual DisplayPort 1.2 interfaces

just to get 8K at 60Hz. Seriously clunky.

That's all set to change this year. BenQ says it will launch its first 8K monitor later in 2022 and Viewsonic's is due soon after. What's more, both Hannspree and Monoprice, both known for their competitive pricing, have hinted at 8K panels in the works. Hannspree has suggested its 8K monitors will be bigger than existing displays.

It's unclear exactly what it plans, but we suspect it could be a 55-inch monitor using a TV panel rotated through 180 degrees to give the correct RGB subpixel layout. Add in HDMI 2.1 and DisplayPort 1.4, crank it out for, let's say, \$2,500 and that's still not chump change for a PC monitor. But what a display that would be. Well worth investing in for years of high-DPI action with an incredible amount of desktop real estate to boot.

While we're talking resolutions, one option is the upcoming LG DualUp 28MQ780. It's an unusual 16:18 aspect panel with 2,560x2,880 pixels and is designed to deliver increased vertical space in a world of ubiquitous widescreen monitors. A niche option? For sure, but interesting all the same.

If that's affordable high-refresh 4K and 8K multi shapes and sizes covered off, what else can you expect in 2022? LCD monitors with mini-LED full-array backlights are going to be more widely available. As we've already implied, mini-LED full array backlighting is never going to be as good as a true per-pixel technology like OLED for controlling light output. But done right it can give impressive results when it comes to contrast. Mini-LED is also capable of greater brightness than current OLED

CONNECT FOUR DISPLAYPORT AND USB UPS THE ANTE

As resolutions and refresh rates climb ever higher, display interfaces are becoming more critical than ever. Already, it's only the very latest AMD and Nvidia graphics cards that can drive a 4K display at 120Hz over HDMI. At full 4:4:4 chroma and 8-bit colour, that requires fully 32Gbps of raw bandwidth.

Now imagine what's required for 8K and the usual 60Hz. Then

double that for 8K 120Hz. Now we're talking crazy numbers. As it happens, both HDMI 2.1 and DisplayPort 1.4 have the bandwidth minerals, so to speak, for 4K at 120Hz, but compression is required for 8K@60Hz. HDMI 2.1 can actually go as high as 10K (10,420x4,320 pixels) with compression.

Anyway, once you also factor in the bandwidth requirement of

HDR, it's clear that new interfaces are going to be required soon enough.

For the PC, that means DisplayPort 2.0. It increases bandwidth over the existing DisplayPort 1.4 standard from 32.4Gbps raw and 25.92Gbps effective to fully 80Gbps raw and 77.37Gbps effective.

So, it can go beyond 60Hz at 8K without compression, along

with supporting 8K at 60Hz with HDR and 144Hz 4K with HDR. As for what it can achieve with compression, how about a 16K panel? Nice.

The other critical piece of the connectivity puzzle is USB. Already, USB-C with DisplayPort alt mode is becoming extremely popular thanks to its ease of use and ability to deliver power, allowing a single cable to connect



tech and gives better bright-scene HDR performance than an OLED panel.

Bright and beautiful

The brightest backlit LCD TVs, for instance, can hit nearly 2,000 nits of full-screen, eye-popping zing, whereas even the latest generation of OLED technology can only manage around 1,000 nits in small, isolated windows. In practice, absolute full-screen brightness isn't hugely relevant. But in brighter scenes, it really matters for HDR performance.

That's because the way that HDR content is mastered takes into account the limitations of human vision. The process is known as PQ or Perceptual Quantisation and it's based on a granular model of the human eye's ability to perceive two different levels of light. It's all rather technical, but the bit you need to know is that when a display cannot achieve the brightness anticipated when the content was mastered, details in bright areas bloom out or bleed into one another.

The result is a loss of detail. A good example involves clouds in a bright sky. On an OLED panel they tend to bleed into a featureless white mass, with the finer elements lost as large areas flatten out, whereas, on the best LED-backlit LCD screens, you can see lots of fine, wispy detail and features.

Anyway, in this category of mini-LED monitors that promise outstanding HDR performance, the AOC AG344UXM and ViewSonic XG341C-2K should be interesting for gamers. Both are IPS monitors due this year and have the same basic form as the Alienware AW3423DW

OLED panel. So that's 34-inch ultrawide and 3,440 by 1,440 pixels. The AOC will be good for 170Hz, while the Viewsonic will crank out 200Hz.

Both have mini-LED backlights with 1,152 zones and so should be able to deliver a true 1000-nit HDR experience rather than the pseudo-HDR that comes with DisplayHDR 400 panels only capable of 400 nits of brightness and which typically lack local dimming of any kind, let alone hundreds of mini-LED zones.

The Samsung Neo G8 looks pretty hot, too. Due any day now, it's a 32-inch 4K model with a 1,196-zone mini-LED backlight that's good for a whopping 240Hz. If that's likely to be pretty pricey, the likes of the Acer Predator X27S and Cooler Master GP27-FQS should be more attainable. Both are 27-inch 1440p models running at 160Hz powered by 576-zone mini-LED backlights. Overall, expect plenty more mini-LED monitors this year and hopefully at ever-lower prices.

If you're getting the sense that higher refresh rates are becoming the norm, that's going to be even more true as 2022 progresses. How much ever higher refresh matters for most gamers once you get beyond, say, 240Hz is open to question. But multiple 360Hz monitors are already available with 480Hz incoming, quite possibly by the end of 2022. Both LG and AU Optronics are close to releasing 480Hz IPS panels to monitor manufacturers. They're both expected to be 1080p 24-inch models, aimed at serious eSports addicts and pro gamers. Of broader interest, LG is working on a 1440p

panel with a refresh rate beyond 240Hz. That should be out this year and sounds pretty sweet on paper.

Beyond all that, there will inevitably be detailed further improvements to existing LCD panel tech. LG debuted its so-called IPS Black high contrast technology in the Dell U3223QE earlier this year, which we reviewed recently. While it disappointed on first viewing, here's hoping future implementations improve. The one thing IPS tech could do with is a contrast boost and better native black tone rendering.

LG is also working on further improving both the pixel response and color accuracy of its IPS panels, including exceeding 100 percent of the DCI-P3 digital cinema space, which will be impressive if it happens. In terms of response, LG is planning on reducing the overshoot and inverse ghosting that results from heavily overdriven pixels, which in turn should improve the usable response time. LG hasn't divulged any specifics, but we'd estimate it will release its first 0.5ms GTG, rather than the even more forgiving MPRT metric, IPS panels. Here's hoping.

Still, if you add up all of the possible developments for conventional LCD tech in 2022, you arrive at a pretty spectacular overall solution, even without OLED becoming more widely available. If 2022 won't quite be the year of cheap OLED monitors for all, it is shaping up to be a good time to buy a new PC monitor. ■

"The brightest backlit LCD TVs, for instance, can hit nearly 2,000 nits of full-screen, eye-popping zing"

Hmmm, upgrades: USB is about to get a 240W power up, plus more bandwidth.

a laptop, drive the display, charge the laptop itself and connect peripherals. As resolutions and refresh rates increase, of course, USB will need to keep up.

As it is, the existing USB 3.2 standard tops out at 20Gbps. But USB 4 doubles that to 40Gbps, significantly increasing your display options.

Just as important, the USB

Implementers Forum recently announced a new Extended Power Range (EPR) definition known as USB-PD R3.1. This promises to increase the maximum power delivery for USB-C charging from 100W to fully 240W. The existing 100W limit isn't nearly enough for powerful gaming laptops. But the increase to 240W will make it truly viable to run a high-

performance portable via USB-C.

The only snag is that delivering that much power creates some practical problems. To prevent shorting and arcing, especially when unplugging, new cables are required.

Part of the solution is to make the CC and VBUS pins different lengths, thereby allowing the detection of disconnect events

quickly enough to enable the power source to reduce current before the cable is completely disconnected.

A snubber capacitor installed at both cable ends is also part of the new EPR standard and this will help to ensure the new turbocharged USB interface doesn't send sparks flying every time you pull the plug.

COVER FEATURE

GPU Buyer's Guide

Eight years of graphics cards put to the test, by Jarred Walton.

The past two years of pandemic-induced scarcity and supply chain disruption, coupled with cryptocurrency mining mania, have for many dashed hopes of a new graphics card. Nearly 18 months after the launch of AMD's Radeon RX 6000-series and Nvidia's GeForce RTX 30-series GPUs, Steam data shows only 15 percent of gamers use Ampere cards, and under one percent use AMD's RDNA 2 chips.

But plenty of graphics cards are still fast enough to play today's demanding games. To help put things in perspective, we rounded up all the major GPUs from the past six years (plus a few from further back) and put them to the test. Which cards still have staying power and which have fallen by the wayside? Our requirement is that each card needs to work with Windows 11, so join us as we delve through GPUs past.



From ultra-budget offerings to extreme Titan cards and everything in between, we've put in hours of benchmarking to bring you a guide to GPU hierarchy.

Welcome to the modern era

Midway through 2022, Windows 11 is coming up to its first anniversary and it looks as though the pandemic may finally be subsiding. It's also the second anniversary of the current graphics architectures from AMD and Nvidia, RDNA 2 and

Ampere, so it's a good time for a look at the state of the GPU industry. But we're not just interested in the latest offerings, we want to see how previous-generation GPUs stack up, so we've rounded up a huge collection of graphics cards and tested every one in a

system that's about as modern as it comes.

We're running a Core i9-12900K CPU, cooled by a Corsair H150i Elite Capellix AIO. Our motherboard is an MSI Z690-A Pro WiFi DDR4, a small concession to sanity since

DDR5 prices are high and the change in memory doesn't necessarily improve performance. We have 2x 16GB of Corsair DDR4-3600 16-18-18 memory, which has worked flawlessly with the XMP profile enabled, and a large and spacious 2TB M.2 PCIe 4.0 SSD in the form of the Crucial P5 Plus. All of this is powered by a 1200W Cooler Master 80 Plus Gold PSU, which might have seemed overkill until Nvidia rolled out the RTX 3090 Ti.

Using a state-of-the-art CPU and motherboard with many of the graphics cards we've collected won't matter much for performance, but we wanted to show every GPU in the best light possible. The Core i9-12900K reigns as the fastest CPU for gaming purposes, thanks to its high single-threaded performance and clock speeds. We'll still encounter CPU bottlenecks in some games, such as *Microsoft Flight Simulator* when running at 1080p, but we've tried to remove them.

We could have tested at higher resolutions to ensure that the CPU isn't the limiting factor, but that presents a completely different set of problems. Modern GPUs with more than 8GB of VRAM might be

able to run maxed out settings and resolutions up to 4K, but older and slower GPUs are another story. Even with limiting our testing to 1080p, running ultra quality settings wasn't possible in at least one game, *Red Dead Redemption 2*, unless the card had at least 4GB. That sets the stage for the results, but first, let's talk about the games we're testing.

We've benchmarked eight games in our standard test suite: *Borderlands 3*, *Far Cry 6*, *Flight Simulator*, *Forza Horizon 5*, *Horizon Zero Dawn*, *Red Dead Redemption 2*, *Total War: Warhammer 3*, and *Watch Dogs Legion*. In addition to those, we also tested six more games on cards that have hardware ray tracing support: *Bright Memory Infinite*, *Control Ultimate Edition*, *Cyberpunk 2077*, *Fortnite*, *Metro Exodus Enhanced Edition*, and *Minecraft*. All six games use multiple ray tracing effects, which we feel is important to highlight the image fidelity and performance requirements of RT hardware.

Every GPU was tested multiple times at each setting and scores were selected after eliminating any outliers, to provide the best set of comparable results. We also tested

"Using a state-of-the-art CPU and motherboard with many of the graphics cards we've collected won't matter much for performance, but we wanted to show every GPU in the best light possible."

GPU STATE OF PLAY

Performance at 1080p ultra (FPS)

Over 50 GPUs, spanning the past five generations of GPU architectures, put to the test.



* Gpu could not run all of the test due to insufficient VRAM

at higher resolutions, where it makes sense. The total amount of data gathered includes thousands of benchmark runs, conducted over several months, using the most up-to-date drivers available at the time of testing.

Our choice of hardware wasn't without its problems, particularly on some of the older graphics cards.

Enabling resisable BAR support in the motherboard BIOS as an example caused the Radeon VII to refuse to even POST (Power On Self-Test), even though it doesn't even have the hardware and software support to benefit from the feature. Disabling the settings (with a different GPU installed) fixed that, which is a configuration probably few if any people will ever try. Overall, though, we were pleased to see that we encountered relatively few quirks.

Please check your drivers

Driver support represents a potential hiccup when trying to use an older graphics card on Windows 11, or even with Windows 10. AMD still has current driver support for everything back to its RX 400-series GPUs with its latest

drivers. That covers graphics cards from Team Red dating back to 2016. What about the older stuff, like the 300-series and 200-series parts from 2014 and 2013, or even the newer R9 Fury family from 2015? Windows 11 will download drivers for that hardware, but the last driver update from AMD came in May 2021, so you may encounter some incompatibilities with more recent game releases.

Nvidia's driver support extends further, with the current release supporting everything back to the GTX 900-series. That means any GPU from Team Green made in the past eight years should still have

support, and the GTX 700- and 600-series cards got a final driver release last September – and a security patch was released in January for those GPUs. Conceivably, you could run a graphics card from a decade ago on a modern PC and it will still work... most of the time.

Of the games we tested, a few complained about outdated drivers on some of the legacy GPUs. Despite the complaining, most of the games still ran just fine, but *Forza Horizon 5* failed to run using the default drivers that Windows 11 installed. The solution was to download the latest Windows 10 drivers, and then

GPUs aren't just for games, with supercomputers using them for weather simulations, deep learning AI routines, and more.

INTEL ARC PREPS FOR A FLOOD

The big two GPU names are about to get some much-needed competition from Intel's Arc, or at least in theory.

Arc, formerly DG2, aka Xe-HPG, has seen quite a few delays. We originally thought it would launch by the end of 2021, but now it's looking like a mid-2022 launch for the desktop parts. It could be too little, too late for gamers, though the media aspects of the chips remain promising.

Intel recently revealed the initial lineup for laptop Arc A-series models, which will inevitably be paired with Intel CPUs. Given Intel dominates the laptop landscape in sales, it's probably a smart business move, but it doesn't give us a lot of hope for high performance.

Intel compared its lower-tier A370M part against its own integrated Iris Xe Graphics, from a Core i7-1280P. That's a 28W mobile chip with 96 Execution Units (now called XVE, for "Xe Vector Engine"), going up against a 35–50W A370M with

96 of the new XVEs. Performance was over 50 percent faster, but our previous testing suggests that will be quite a bit slower than even a GTX 1050.

The highest tier Arc chip, A770M, will come with 512 XVEs and faster memory. That's 4,096 shader cores and a potential compute performance of 13.5 TFLOPS FP32. Theoretical performance isn't the same as real-world performance, but even in a best-case scenario, that puts the A770M on par with Nvidia's mobile RTX 3070.

Intel isn't just talking about graphics performance, however. Arc also includes XMV units (Xe Matrix eXtensions), which are basically Intel's equivalent of Nvidia's Tensor cores. Each XMV can perform 128 FP16 operations per clock, so the A770M has a peak throughput of 108 TFLOPS for deep learning



and AI acceleration. Intel will be using the XMV engines for its XeSS (Xe Super Sampling) upscaling algorithm, which sounds a lot like DLSS. XeSS will also be able to run on DP4a (INT4) hardware, for non-Arc GPUs including AMD RDNA and newer and Nvidia Pascal and newer architectures.

Finally, Intel will include up to 32 ray tracing units (RTU) in its top Arc GPU. Unless Intel's RTUs are far more potent than

those of Nvidia or even AMD, we don't expect much from Team Blue when it comes to its first generation of ray tracing hardware. The lowest tier Arc A350M for example has just six RTUs clocked at 1150MHz, with 4GB VRAM on a 64-bit interface. Based on those specs, it might make even the RX 6500 XT look fast. We'll find out just how the Arc chips stack up in the real world in the coming months, but we have a sinking feeling.



As with cars, putting the wrong driver at the wheel can be a recipe for disaster with graphics cards.

the game ran fine. Note that while there are still plenty of people gaming on older CPUs, graphics cards tend to not age quite so well. Even if there aren't driver issues, modern games push the hardware in new and demanding ways, and sometimes older GPUs simply fall flat on their faces. But if you're just trying to play Fortnite or other less demanding games and you're willing to drop the settings and resolution, even relatively ancient hardware can still get the job done – assuming you didn't kill the GPU with crypto mining, naturally.

Gaming performance over time
You won't be shocked to see a clear trend of improving performance through the generations of hardware. Today's RTX 3090 Ti basically doubles the performance of the GTX 1080 Ti, and the same goes for the RX 6900 XT and the two-generation old RX Vega 64. Go back another generation to the R9 Fury X and the GTX 980 Ti and the gap becomes even larger, with modern high-end cards like the RTX 3080 and RX 6800 XT more than tripling the performance of the fastest cards in 2015, the GTX 980 Ti, and R9 Fury X.

As impressive as that is, let's keep

things in perspective. The fastest GPUs in 2015 packed 8 billion transistors into a 601mm² die size, the GM200 used in the GTX 980 Ti. Today's GA102 that powers the RTX 3090 Ti sports a whopping 28.3 billion transistors – 3.5 times as many – in a chip measuring 628mm². Clock speeds have improved from 1.2GHz in 2015 to nearly 2GHz for Nvidia on the RTX 30-series, while AMD has boosted clocks from over 1GHz on the R9 Fury X to over 2.5GHz on the fastest RX 6000-series GPUs.

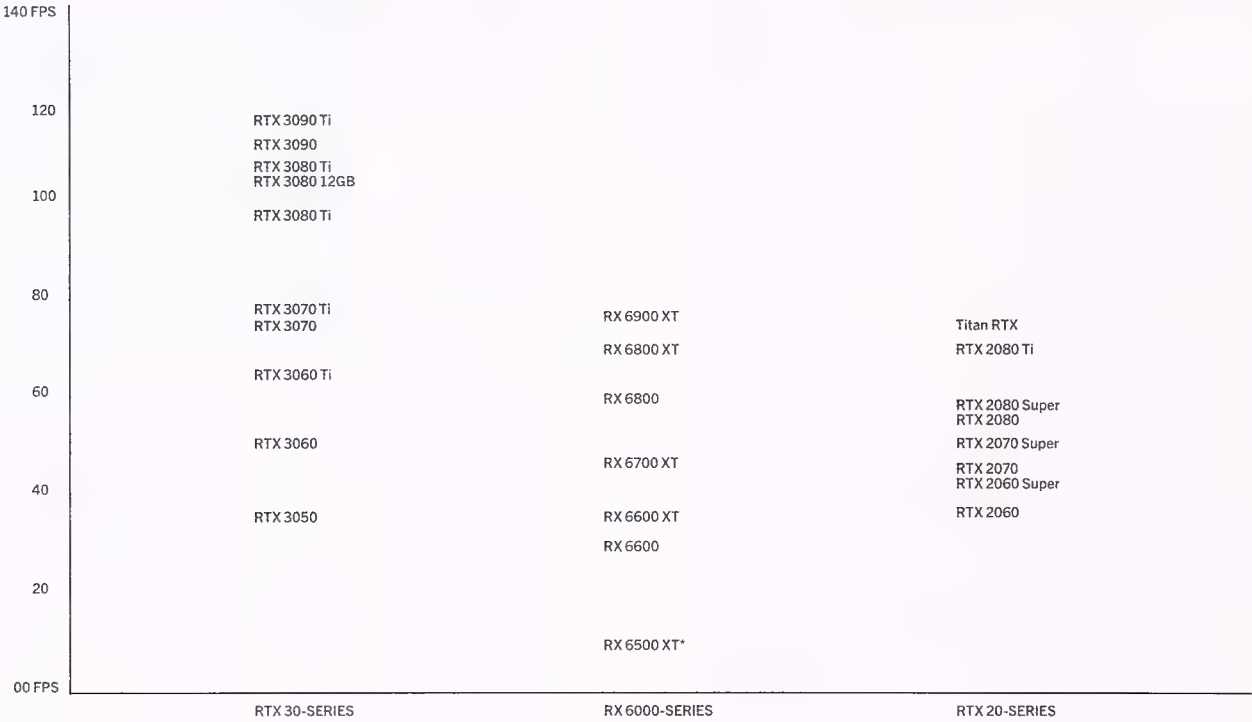
In other words, looking at transistor counts and clock speeds, GPUs haven't even managed to achieve linear scaling. We have larger chips, with lots more transistors, running substantially higher clocks, but performance has started to taper off. On the other hand, today's chips do a lot more than those of six years ago, with features like ray tracing and DLSS.

Another way of looking at it is to focus on a specific level of GPU, like Nvidia's 980, 1080, 2080, and 3080. Here's where the end of Moore's Law and Dennard scaling become more obvious. The 1080 boosts performance by 84 percent over the

© Getty Images/RichVintage

GPU STATE OF PLAY
Ray tracing performance at 1080p medium (FPS)

Only Nvidia RTX cards and AMD RX 6000 GPUs can run our full ray tracing test suite.



* Gpu could not run all of the test due to insufficient VRAM

The best extreme, high-end, midrange, & budget GPUs

Going all out on pure performance might sound great, but most people need to strike a balance between framerate and cost. Putting everything together, we've picked the four best options for various budgets, keeping in mind that graphics card prices still aren't completely back to normal. If you need something right now, here's what we recommend, though waiting for the next-generation cards to arrive later this year should provide more bang for your buck.



BEST EXTREME GPU ■ \$3,500

GEFORCE RTX 3090 TI

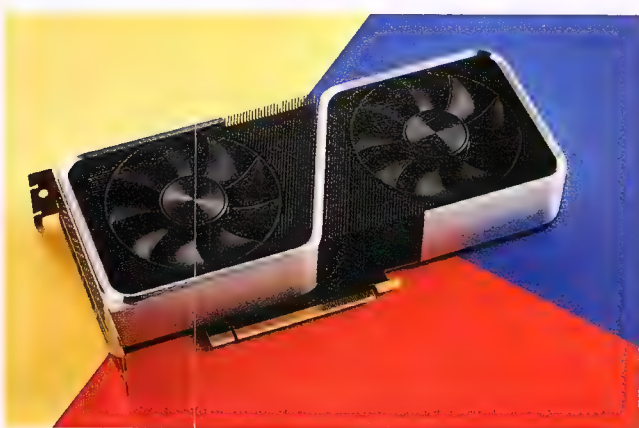
When your only goal is to get the fastest graphics card possible, the choice is simple. Nvidia's latest and greatest might not be particularly efficient, and your wallet might go on strike, but there's no question this represents the current pinnacle of GPU performance. The law of diminishing returns is in full effect, so paying about three times as much as our high-end pick will only get you around 35 percent more performance. Thanks to Nvidia's DLSS, however, you can generally break 60 fps at 4K even with demanding ray tracing games.



BEST HIGH-END GPU ■ \$1,400

RADEON RX 6800 XT

One and a half years after launch, AMD's Radeon RX 6800 XT is a compelling option, particularly if you're not convinced of the need for maxed-out ray-tracing settings – if that is something you care about, the RTX 3080 is a close second for this category. You'll get 16GB of VRAM, which should be plenty for the next few years, and AMD's prices make this a better value than other options. Street prices are close to \$1,400 at the time of writing, but prices have been dropping by 10 to 15 percent per month this year. Hopefully, as you read this, cards will be under \$1,200.



BEST MIDRANGE GPU ■ \$820

GEFORCE RTX 3060 TI

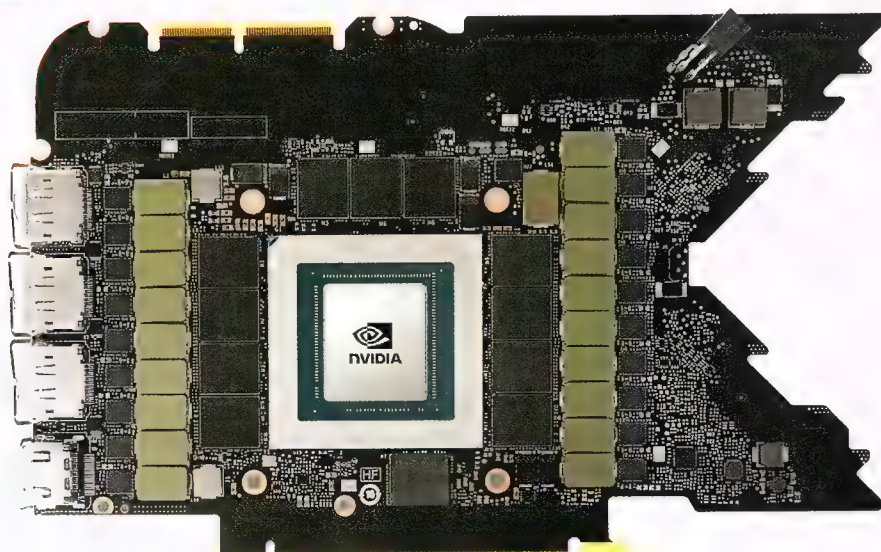
The RTX 3060 Ti almost seemed too good to be true. It was faster than the previous generation RTX 2080 Super and only marginally slower than the 2080 Ti. Of course, thanks to the usual culprits, including global shortages and crypto-miners, the RTX 3060 Ti ended up selling for \$1,200 or more during most of last year, however, prices are finally coming down – and fairly rapidly too. If you want to save even more money, check out the non-Ti 3060 with 12GB VRAM. This was an extremely close runner-up in our tests and was available for under \$700, at the time of writing.



BEST BUDGET GPU ■ \$520

GEFORCE RTX 3050

"Budget" means different things to different people, but we prefer to pay a bit more for substantially improved features and performance. The RTX 3050 rates as the slowest ray tracing card that's still worthy of consideration, with a very competitive price. The GTX 1660 Super only costs slightly less, but it's slower and can't run ray tracing games worth a spit, plus the RTX 3050 still supports DLSS and can get a healthy performance boost in games that support the technology. If you can't stomach the price, you'll probably want to stick with whatever you currently have and save up money rather than pinching pennies.



The GeForce RTX 3080 Ti has 12 GDDR6X chips surrounding the GPU to help feed the beast.

980, the 2080 is 55 percent faster than the 1080, but the 3080 is only 40 percent faster than the 2080. AMD's GPUs tell a similar story, the shape of things to come.

The other end of the performance spectrum tells a mixed story. The RTX 3050 more than triples the performance of the GTX 1050, but we're looking at a budget card from five years back going up against a midrange card that costs more than

twice as much – there's no actual 'budget' RTX 30-series offering so far.

AMD's budget GPUs show an even more perplexing story, with the RX 5500 XT doubling the performance of the RX 560, but then the latest RX 6500 XT takes a step backward from there – and both of the newer generation cards carry substantially higher prices than the launch price on the RX 560 4GB. Of course, you

don't need to run maxed-out settings (see sidebar on ultra quality), but if you're already running medium settings, you'll be in need of an upgrade sooner than later.

The need for more VRAM

One noteworthy change that we've seen repeatedly through the years is the need for more VRAM. There was a time when people were debating between 1GB and 512MB graphics cards and, before that, we argued about 128MB vs. 64MB. Today, we've reached the point where 4GB is barely sufficient to run all of our benchmarks and there are several games in our test suite that will warn about the lack of graphics card memory – *Far Cry 6*, *Forza Horizon 5*, and *Watch Dogs Legion* can even suffer from degraded performance with 8GB of VRAM! Game developers clearly want more VRAM for their purposes, and with high-resolution textures, more detailed models, and technologies like ray tracing, 8GB represents the bare minimum of what we want to see on any midrange or higher GPU.

YOU DON'T NEED ULTRA QUALITY

Depending on the game, the difference in visual fidelity between medium settings and ultra settings may not be worth the performance penalty.

Those running extreme GPUs, like the RTX 3090 or RX 6900 XT, can safely set phasers to vaporise and carry on. But if your GPU is long in the tooth, dropping the settings a notch or two can do wonders for performance – particularly if you're using a graphics card that doesn't have at least 4GB VRAM, and some recent games even want 8GB just for 1080p ultra.

Take the GTX 1050, which sits at the bottom of the rankings in terms of 1080p ultra-performance and delivered just 15fps on average. Dropping to 1080p medium doubled its performance, and while a few games still struggled – *Warhammer 3* and *Flight Simulator* still failed to break 30fps – most games are at least playable.

What can you expect from medium-quality visuals compared to ultra quality? There's a bit less of all the finer details, like shadows and



reflections, but in some games, the ultra settings feel like a placebo. The Xbox One and PlayStation 4 essentially run at settings comparable to medium quality in most games, and millions of console users still enjoy playing games on those

systems. 30fps at 1080p medium might not be much to brag about, but if the only other option is not to play, don't be afraid to give it a shot.

Similarly, if you aren't rocking top-shelf hardware, you'll be far better off running at 1080p than

at 1440p or 4K. Even if you have a 4K monitor, playing games at 1080p is a reasonable option, and upscaling technologies like AMD's Radeon Super Resolution (RSR) and Nvidia Image Scaling (NIS) can still provide a pleasing result.

If you want a great example of the difference more VRAM can make, just look at the R9 390 and GTX 980.

Back in 2015, when the newly released R9 390 was running the games of that era, there was no question about which was faster – the Nvidia card was consistently about 10 percent faster. Fast forward to today and the R9 390 with its 8GB now leads the GTX 980 by three percent at 1080p, and the lead grows at 1440p (not that either card is really playable at 1440p ultra these days). Similarly, the Fury X used to be nearly 30 percent faster than the 390, but now that lead has shrunk to 19 percent, and the two cards are virtually tied for performance in *Far Cry 6* and *Forza Horizon 5*.

Cards with 6GB of memory strike an interesting middle ground. There are still times when it's not quite sufficient for ultra settings, but the GTX 1060 6GB as an example outpaces the GTX 980 by 12 percent in our modern suite of games, where it was a few percent slower than its predecessor back in 2016.

Going forward, we've mostly reached the end of the road for 4GB cards. They still have a place in the budget sector, but the RX 6500 XT would have benefited greatly from having more memory and a wider memory interface. 8GB cards are still generally safe, but there are certainly games where you'll want to drop a

few settings (like texture resolution) to avoid memory thrashing – where there's too much data needed in the GPU's VRAM, and it ends up having to pull in data over the much slower PCIe bus. At the same time, going beyond 12GB definitely isn't needed in our current test suite, and while it's inevitable we'll eventually see consumer graphics cards with 32GB or more memory, that's many years away from becoming close to mainstream.

Four years of ray tracing

Who doesn't love eye candy? With its GeForce RTX graphics card launch in 2018, Nvidia ushered in the era of real-time ray tracing for games. Since then, the rate of adoption has been more of a slow burn. We all know what ray tracing – or the more advanced path tracing – can do for movies, but getting similar results at real-time framerates remains difficult.

We've selected the best showcases for ray tracing in games, with multiple RT effects including shadows, global illumination, reflections, ambient occlusion, and caustics. Ironically, perhaps the best example of what full RT can do comes in the form of *Minecraft*, which normally runs on everything including your old and moldy potato PC sitting in the corner.

Nvidia says the enhanced version of the

AMD & NVIDIA GPU FEATURES

The latest generation GPUs from AMD and Nvidia both support ray tracing and the full DirectX 12 Ultimate feature set, which defines the baseline of what we expect to see going forward. Nvidia still has some extra hardware in its tensor cores, which power technologies like DLSS (Deep Learning Super Sampling) and Nvidia Broadcast, and those are both useful additions.

AMD offers something of an alternative to DLSS with its FSR technology, which is due for a major update in the not-too-distant future. FSR 2.0 will move to a temporal upscaling solution, but it will still work on a wide range of GPUs, including those from the competition.

Intel meanwhile has XeSS (Xe Super Sampling), which sounds an awful lot like DLSS, only done on Intel hardware. But having a software solution such as DLSS or FSR isn't the same as getting it adopted by game developers, and DLSS easily wins in that arena.

Stepping back to earlier generation GPUs can mean giving up features, and in some cases, certain games may refuse to run at all. Of our test suite, *Far Cry 6* was the only game that didn't want to run on one of our legacy GPUs. The GTX 780 lacks the appropriate DirectX feature level, and the game simply failed to run despite our best attempts. Of course, there are also games such as *Metro Exodus Enhanced Edition* that require ray tracing hardware, so you'll need at least an AMD RX 6000-series or an Nvidia RTX card to run it.

Other features that ultimately deliver more performance, like AMD's Infinity Cache, aren't particularly important to the end-user, as speed is often the goal. However, video codec support can be important, especially if you're thinking of using a card in a home theatre setup.

Nvidia currently delivers better overall video encoding and decoding hardware, though Intel's upcoming Arc GPUs will be the first with hardware AV1 encoding and decoding support. Nvidia's Ampere and Turing GPUs support hardware HEVC and AVC encoding and decoding, except for the GTX 1650.

AMD's 6000- and 5000-series GPUs also support hardware HEVC and AVC encoding and decoding, except for the RX 6500 XT.

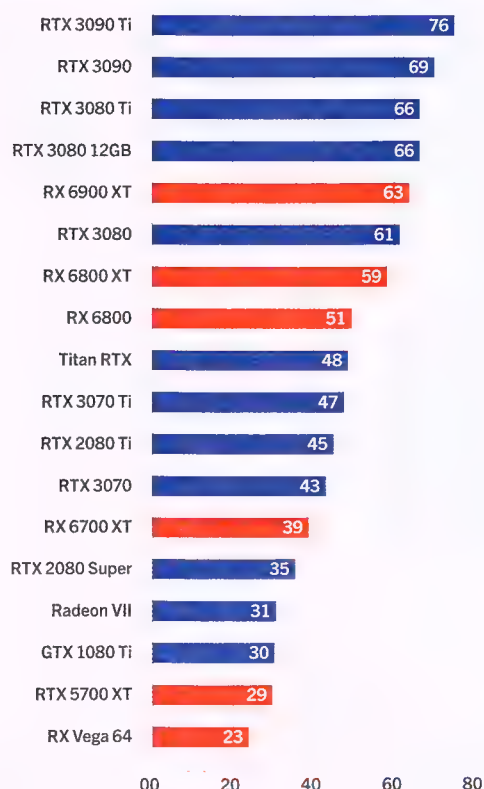
MAXED OUT AT 4K

It doesn't make sense to test most graphics cards at 4K and ultra quality, as the vast majority of older GPUs will gurggle and die while trying to choke down such a workload.

However, for those that have the requisite display and want to know what sort of graphics card they should use, we tested a subset of the fastest 18 GPUs from the past five years. The RTX 3090 Ti naturally claimed top honours, with an even greater lead over the competition than at lower resolutions – CPU bottlenecks are no longer a factor at 4K. It's 10 percent faster than the RTX 3090, and 20 percent faster than AMD's RX 6900 XT.

More importantly, the previous generation's top GPUs came in well below the 60fps mark, with 48fps on the Titan RTX, 45fps for the RTX 2080 Ti, and 39fps from the RX 5700 XT. Going back one more generation, the Radeon VII and GTX 1080 Ti barely managed a 30fps average, with multiple games falling well below that mark.

4K ULTRA GPU HIERARCHY



AVERAGE FRAMES PER SECOND OVER THE GAMES TESTED

game implements full path tracing, which isn't entirely correct, but it does radically alter the visuals with a detailed lighting model that handles reflections, indirect lighting, and more. It also destroys performance, often taking a game that can easily render at hundreds of frames per second without ray

"We need significantly faster hardware if we want to plow through all these ray tracing effects while maintaining high framerates"

tracing down into the sub-60 and even sub-30 range. And that's all for the same base blocky world – getting all of those effects rendering in a more complex game at acceptable framerates simply isn't possible on

today's hardware.

Not surprisingly, since Nvidia was the first out of the gate with ray tracing hardware by over two years, the various RTX GPUs rank at the top of our ray tracing charts. We're using our "medium" ray tracing

settings for the overall standings, which puts Nvidia's top RTX 3090 Ti 50 percent ahead of AMD's top RX 6900 XT. Meanwhile, the slowest ray tracing card so far, AMD's RX 6500 XT, failed to run one of the games (*Control* wants at least 6GB VRAM or you can't even try to enable ray tracing), and couldn't even break 20fps in the remaining games, with *Cyberpunk 2077* and *Bright Memory Infinite* both well into the single digits. We suspect Intel's lowest-tier Arc offerings might be slower than the 6500 XT (see Intel Arc sidebar).

Cranking the settings to maximum proves too much for many of the GPUs, but Nvidia's lead grows to 66 percent at 1080p ultra and 75 percent at 1440p "ultra" – at which point, even the RTX 3090 Ti just barely clears 60fps average across our six-game suite, with half of the games falling below 50 fps. At 4K ultra, the only way to achieve playable performance is with some form of upscaling like DLSS; native 4K averaged just 29fps across our suite on the 3090 Ti, and half the games were in the low 20s.

With settings maxed out, *Cyberpunk 2077* averages just 23fps at 4K on the 3090 Ti.

AMD's entry into the ray-tracing space more or less lines up with Nvidia's first-generation RTX cards. The RX 6900 XT delivers nearly identical performance to the Titan RTX, and the RX 6600 comes in slightly behind the RTX 2060. Nvidia didn't even try for budget RT hardware the first time round, and poor Navi 24 shows why. Meanwhile, Ampere's second-generation RT hardware is about 75 percent faster than the Turing RT cores, though the RTX 3050 still ends up being slower than the RTX 2060.

WHAT ABOUT LAPTOP GPUS?

All our testing has focused on desktop graphics cards.

It allows us to test the various GPUs while keeping all other hardware constant, but there are also mobile variants of most graphics cards. As you can guess, packing something like a 450W RTX 3090 Ti into a laptop just isn't going to happen, not without drastically cutting the power use. That results in the latest mobile GPUs from Nvidia and AMD generally being at least one step down in performance from their desktop counterparts.

Take the mobile RTX 3080, for example. It uses the GA104 chip, whereas the desktop 3080 uses GA102. It also has 8GB of memory on a 256-bit bus instead of 10GB on a 320-bit interface and comes with 48 SMs and 6,144 CUDA cores compared to 68 SMs and 8,704 CUDA cores. It typically runs at lower clocks as well. All those cuts are done to keep power consumption under control, and the resulting GPU can be configured to run at 80–150W, depending on the specific laptop and configuration, compared to the base 320W of



Many use laptops for gaming and computing, but going mobile means giving up some performance.

the desktop 3080.

It's a similar story for AMD. The RX 6800M uses the smaller Navi 22 and has 40 CUs and 2560 shader cores, with 12GB of VRAM and TGP (Total Graphics Power) starting at 145W. The desktop RX 6800 uses Navi 21 with 60 CUs, 3840 shaders, 16GB of memory, and a 250W TGP. The specifics of

the various graphics chips over the years may vary, but the net result is the same: lower performance.

The 150W mobile RTX 3080, for example, comes close to the level of a desktop RTX 3070, while the lower limit 80W configuration will often fall behind the desktop RTX 3060 Ti. AMD's

RX 6800M likewise falls behind the desktop RX 6700 XT.

The benefit, naturally, is that you don't fry your nether regions when gaming on the go, though battery life still tends to be far less than two hours for anything that really uses the GPU – no, a text-based *Zork* reimagining doesn't count.



Ray tracing, round three

We need significantly faster hardware if we want to plow through all these ray tracing effects while maintaining high framerates. Thankfully, that should be coming soon with Nvidia's Ada and AMD's RDNA 3 GPUs – and also the Intel Arc wildcard (see sidebar), but we're skeptical it will be competitive. They will probably be the RTX 40-series and RX 7000-series, respectively, but whatever the names, we expect both companies to cram in even more transistors. That's thanks to a switch to TSMC's 5nm process nodes – maybe even "4nm" 4N, though the process names are more marketing these days.

For Nvidia, this will be the third

architecture with ray tracing support.

Ampere added a second ray/triangle intersection pipeline to its RT core, along with some extra hardware to help with more complex ray-tracing calculations like motion blur. Ada will also be the fourth generation of Tensor cores, and we know from the datacenter Hopper H100 (see APC 507 Tech Talk) that Nvidia can create large GPUs with a ton of compute. We don't think the consumer-oriented Ada chips will be quite as extreme as Hopper, but Nvidia could potentially double RT and Tensor core performance yet again.

Alternatively, it might put in more RT hardware and focus less on further boosts to deep learning and AI performance.

There was an Nvidia hack this year that leaked some details about the upcoming Ada GPUs. The biggest chip, AD102, has up to 144 SMs – 71 percent more than the Ampere GA102. Even if Nvidia keeps the same relative performance per GPU core and SM, stuffing in that many SMs should provide a huge boost to performance, regardless of workload. The second tier AD103 chip has the same 84 SM maximum as GA102, but it should be smaller and presumably less expensive to produce, which could lead to some compelling high-end offerings. Take this with a pinch of salt, but we're looking forward to Ada.

AMD hasn't been hacked by LAPSUs, so we don't know as much about the upcoming RDNA 3 architecture. The data center Aldebaran chips powering the MI250X are massive and have matrix cores similar to Nvidia's Tensor hardware, but so far, AMD has been hesitant to embrace machine learning hardware on consumer products. If AMD skips the matrix hardware on RDNA 3, it could potentially cram in more CUs (compute units, similar to Nvidia's SMs). Or it might decide to add matrix cores and look at supporting Intel's XeSS algorithm – stranger things have happened. ■

WHEN TO UPGRADE

It's easy to get carried away looking at the top-performing cards and thinking it's time for an upgrade.

Resist the temptation, at least until the games and applications you're using warrant the expense. Even then, make sure that your 'upgrade' actually represents a true leveling up of performance.

The oft-quoted rule of thumb is that a previous generation GPU represents one step down in performance, but that's not entirely accurate. For Nvidia, the RTX 2080 lands midway between the 3060 and 3060 Ti, the GTX 1080 performs about on par with the RTX 2060, and the GTX 980 lines up with the GTX 1060. That's two steps down, but if you look at the –70 cards, it's maybe one to one and a half steps down, and among the –60 series chips it's sometimes less than a single step, albeit muddled by the Turing GTX 16-series GPUs. AMD has swapped through various naming paradigms so making comparisons is a bit trickier, but the RX 5700 XT matches up with the RX 6600 XT, Vega 64 takes on the 5600 XT, and Fury X matches up with

If your old PC looks like this, you might need more than just a new graphics card.



the RX 580.

If you're sitting on a GTX 1060, which still rates as the most popular GPU according to Steam's hardware survey, it's probably worth thinking about upgrading. Our advice is to try and get a graphics card that's at least double the performance of your current GPU if you want to

feel a big improvement. The RTX 3060 gets you that, as does the RX 6600, but if you can splurge on an RTX 3070 or RX 6700 XT you get triple the performance.

The other thing to consider is when new GPU architectures and hardware will launch. Upgrading right before the new stuff comes out is usually the

worst approach while being an early adopter can mean paying higher prices. Then again, anyone who paid scalper prices for an RTX 3080 after that card launched probably felt good about the decision when prices shot up four months later. Let's hope that never happens again.

THE

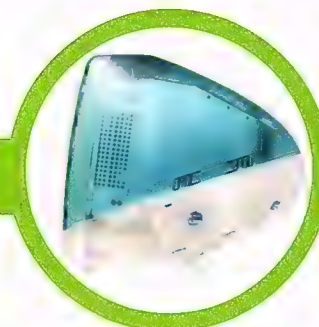
WORLD'S

MOST
ICONIC

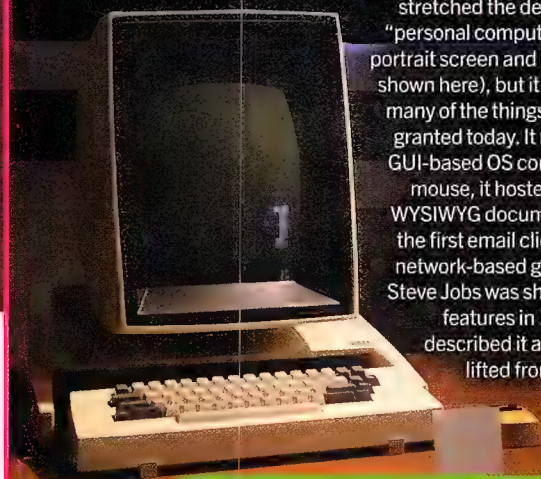
PCs

What do we mean by iconic? Here, we're talking about the influencers. The computers that changed perceptions of what computers could be, or inspired a new type of design.

CONTRIBUTORS: Barry Collins, Tim Danton



The cabinet-sized Alto may have stretched the definition of “personal computer” (only its portrait screen and keyboard are shown here), but it also defined many of the things we take for granted today. It ran the first GUI-based OS controlled by a mouse, it hosted the first WYSIWYG document system, the first email client, the first network-based games. When Steve Jobs was shown its latest features in 1979, he described it as a “veil being lifted from my eyes”



A computer so iconic that it can be recognised by its silhouette, the PET was Commodore's first computer – built to take advantage of the company's own 6502 processor (also used in the Apple II). At that point Commodore was famous for its calculators and typewriters, and its legendary boss Jack Tramiel took some persuading that new-fangled computers were worth a gamble. But thanks in the main to Chuck Peddle, the chip's lead designer, Tramiel rolled the dice and Commodore computers were born.



Although it looks more like a prop from a bad 70s sci-fi movie, the Altair 8800 was the first minicomputer kit. It came in various configurations, but the base spec included a 1,024-byte memory board and Intel's 8080 processor. Fripperies such as keyboard or a display weren't included. It still caught the eye of a keen Harvard student called Bill Gates, who wanted to create a BASIC interpreter for the 8800 and worked part-time for the company, before heading off to start some small firm of his own...





IBM PERSONAL COMPUTER 5150

"Welcome IBM. Seriously." That was Apple's cheeky response, via a full-page ad in The Wall Street Journal, to IBM's first personal computer in August 1981. This machine marked a huge departure for IBM, which had built its post-war reputation and fortune on mainframes and minicomputers. IBM's then chairman Frank Cary was persuaded by Bill Lowe – often referred to as "the father of the IBM PC" – that he could not only create a profitable new product line but build it from scratch in a year. With the help of a certain Bill Gates, who handily kept the rights of the operating system to himself, the rest is history.



COMMODORE 64

Commodore's top-selling home computer, the C64 was the first 64-bit home computer. It featured a custom VICE (Video Interface Chip) and a custom MOS Technology 6581C audio chip. It was the first home computer to feature a custom VICE (Video Interface Chip) and a custom MOS Technology 6581C audio chip. It was the first home computer to feature a custom VICE (Video Interface Chip) and a custom MOS Technology 6581C audio chip.



OSBORNE 1

Wikipedia describes the Osborne 1 as "the first commercially successful portable computer". Given it weighed 11kg (the weight of a propane gas cylinder), the word "portable" is doing a lot of heavy lifting in that sentence. Nevertheless, the Osborne – brainchild of computer book publisher Adam – sold in droves, with its 4MHz processor, dual 5.25in floppy drives and 5in CRT display winning plenty of admirers. At its peak, it was shifting 10,000 units per month.



COMMODORE VIC-20

It's often consigned to the footnotes of history, but the VIC-20 was the first computer to sell a million units, and introduced many people to the wonders of programming thanks to its detailed manual. And eking all they could from the miserly 1.5KB of available memory. Perhaps most crucially, it proved to the Commodore board that there was a home computing market to be attacked along with the businesses that had embraced the PET. Next stop, the Commodore 64.

BBC MICRO

Realising the importance of computers in the early 1980s, and the new era of skills demanded, the BBC commissioned not only a TV series on computer literacy but also its own computer and BASIC. That way, people could follow its programmes with confidence rather than rely on someone else's hardware and software. It chose Acorn Computers to partner with, and before long a BBC Micro was in every UK school and its use and influence was felt worldwide.



1980

1981

1981

1981

1982



EPSON HX-20

There are several computers that have claimed the "world's first laptop" crown, among them the Epson HX-20. Whether a computer with a screen that spans a mere four lines of 20 characters each can be classed a laptop is debatable, but it's impressive that it also includes a tiny printer next to the display, albeit one that sounds and behaves more like a shopping till. Nevertheless, that Epson packed this all into a 1.6kg unit is impressive for the time, not least because the entire thing could run for hours off four AA batteries.



AMSTRAD CPC 464

Anyone who has watched *The Apprentice* will know that Alan Sugar is a man easily riled, and in 1983 his ire was directed at the likes of Sinclair. If nerdy oiks like Sir Clive could make big money from computers, then so

could he. And he would do it by delivering a complete system that didn't need to be plugged into a TV. The small matter of creating the computer fell mostly on Roland Perry, who – in best A-Team style – set about creating an ace collection of programmers and electrical engineers to deliver the project. His plan came together, with the CPC 464 going on to sell millions of units over its six-year life.

COMPAQ PORTABLE

The Compaq Portable stretched the definition of that word: it weighed 16kg, which is ten times heavier than today's MacBook Air. However, let's not lose focus of the fact this is 1983 and a computer that can be lugged around like a small suitcase is still a minor miracle. The Portable had a 9in green screen, 128KB of RAM and could accommodate two 5.25in floppy drives. It didn't have a battery, so like a portable TV, you still had to plug it into the wall, but despite its shortcomings this IBM-compatible was a big hit at the time.



SINCLAIR ZX SPECTRUM

It's not often you'll find journalists willing to heap praise on the ZX Spectrum – those rubber keys were about as useful as super-gluing your fingers together when it came to bashing out copy. However, we can forgive almost all of the dinky Speccy's flaws. It was a ridiculously cheap introduction to home computing for many, with the 16K model costing less than \$200 if you knew where to look. Yes, the limited colours bled into one another; yes, you needed to plug in an external tape cassette to load games; yes, the sound was comparable to a faulty dishwasher – but it was the 1980s and everything was rubbish.

APPLE MACINTOSH

Having been kicked off the Apple Lisa project, the Mac turned Steve Jobs' fortunes around. Leading a small but talented team, his obsessive attention to detail and sheer charisma helped create a truly revolutionary computer. Complete with a graphical user interface and a one-button mouse, it was easy to get along with. When Jobs introduced the Macintosh he allowed the computer to history speak for itself, thrilling the crowd of Apple shareholders. It took a while for the Mac to live up to everyone's heightened expectations – disappointing first-year sales, due in part to the paltry 128KB of RAM in those first models, led Jobs to leave Apple and start NeXT – but the Macintosh is arguably the most iconic and influential computer ever made.



1982

1982

1983

1984

1984



AMSTRAD PCW

The Amstrad PCW was no oil painting, as the company's irascible owner might say. It was, however, a bargain. \$700 wasn't pocket money in 1985 (it would be around \$2,300 today), but for that you got the PCW, a printer, word-processing software and a bunch of utilities. It had its idiosyncrasies – the use of 3in rather 3.5in floppy disks for one – but the PCW sold in its millions to a generation seeking affordable computing.

ATARI ST

Amiga or Atari ST: which horse did you back? The ST was one of the great PCs of the pre-Windows era and found a niche in several industries. Its built-in MIDI ports made it popular with musicians: Cubase and Logic Pro both started life on the Atari ST, Fat Boy Slim recorded his 'You've Come A Long Way, Baby' album on one, all stored on floppy disks (you can watch a video of how he did it at bit.ly/333fatboy). It was a home gaming machine, too. If you've never played *Kick Off 2* on an ST, you haven't lived.



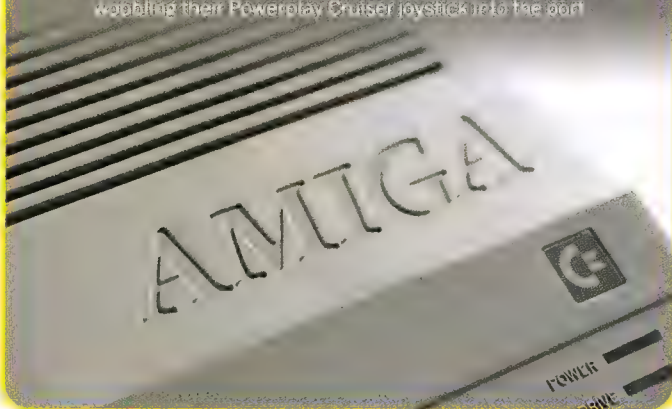
TOSHIBA LIBRETTO

A full decade before netbooks turned up, Toshiba's Libretto range was defining the compact laptop. About the size of a chunky hardback book, these little laptops slotted in between the PDA and laptop market of the time. The Libretto range was more popular in the Far East, and several Librettos were only released for the Japanese

market, including the debut model. To squeeze a full-blown laptop into a device weighing less than a kilo was some feat at the time, even if the 6.1in screen now seems almost quaint.

COMMODORE AMIGA

The Amiga may have arrived in the mid-eighties, but it didn't really become a mainstay of back bedrooms until the 500, 600 and (Dad got a promotion, did he?) 1200 arrived in the early 90s. These beige beauties dominated the home computing landscape until Commodore infamously ran into financial woes in the later half of the 90s. APC readers of a certain age will remember boxes full of ripped-off games on floppies, wrestling with Workbench and wobbling their Powerplay Cruiser joystick into the port.



IBM THINKPAD

The distinctive ThinkPad has been an unmistakable mainstay of the laptop market ever since it arrived in the early 1990s. That iconic red trackpoint in the middle of the keyboard remains a must-have for many buyers, even in the age of super-smooth trackpads the size of swimming pools. The ThinkPad keyboards have always been top-notch, even after the range was sold to Lenovo. And who can forget that slide-out Butterfly keyboard that adorned the ThinkPad 701 in 1995?



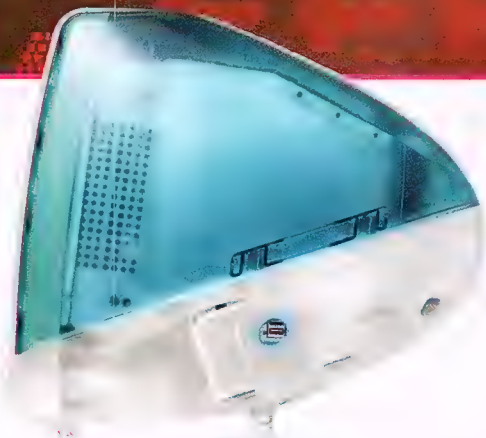
1985

1985

1985

1992

1996



APPLE iMAC G3

Without the original iMac, none of the other Macs on this list would ever have been made. This was the computer that saved a company, arguably the most iconic PC of them all. It was so starkly different to the beige boxes of the time that you couldn't help but admire its transparent plastic casing, which eventually came in all manner of striking colours and patterns. The iMac wasn't only a design classic, it was a boundary pusher. It propelled floppy disks into landfill, for example, and helped to standardise the USB port.



APPLE MACBOOK PRO

The MacBook Pro has not only set the standard for pro-grade laptops for over 15 years, it's been the vehicle for a series of Apple innovations. It was the first laptop to include the MagSafe connector, preventing laptops being yanked off desks when a foot gets tangled in the power cord — an innovation that Apple recently reintroduced on the M1 MacBook Pro. It was also the first laptop to incorporate the unibody design that's now commonplace, as well as the less successful Touchbar.

APPLE iMAC G4

It's 20 years since the iMac G4 was launched, yet it still looks like something from the future. The domed base contained all the computing power, while the metal arm allowed the screen to be positioned at virtually any angle. The 15in screen looks tiny by today's display standards, although it's easy to forget there was a widescreen 20in version that didn't look quite as comfortable in its skin. The G4 was the mainstay of reception desks in fashionable London offices for quite a few years, before it was discontinued abruptly in 2004.



ALIENWARE AREA 51 PREDATOR 1

If a gaming PC isn't a riot of outrageous RGB lighting these days, we're faintly disappointed. In 2003, however, PC cases were a lot more mundane, which made the Alienware Area 51 a true icon of its time. Looking like a prop from the Alien set, the rounded lime green case was fitted with the kind of grilles you'd normally find on a Porsche, making the whole thing look like a giant alien's head. The internals were equally punchy, but the fact those cases are still changing hands on eBay today tells you all you need to know about the design. Little wonder that boring, corporate Dell bought the brand wholesale in 2006.



ASUS EEE PC

There was a time there when cheap, tiny laptops were all the rage. The Asus Eee PC kickstarted the netbook era, prompting a flood of copycats. In the pre-tablet, nascent-smartphone age, buyers couldn't get enough of them as cheap ways to get on the internet. The dinky Eee PC wasn't much to look at, and buyers soon tired of netbooks' sluggish performance, cramped keyboards and small screens. But for a couple of years, netbooks flew off the shelves, and the Asus Eee PC was the one that set the ball rolling.

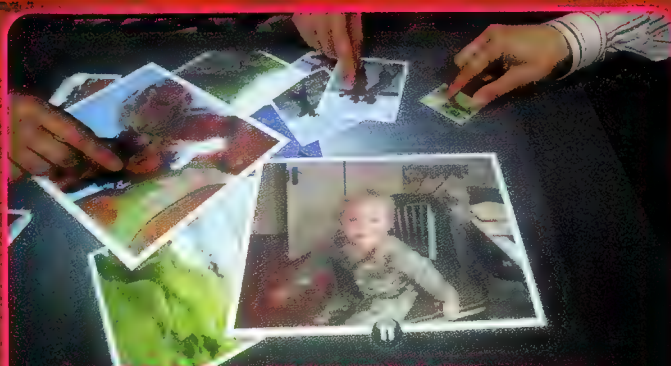
1990

2002

2003

2006

2007



MICROSOFT SURFACE TABLE

Microsoft's first Surface wasn't a tablet, it was a table. A \$10,000 cabinet-sized slice of the future, or so Redmond wanted us to believe. It was an astounding piece of touchscreen technology in an era when touchscreens were still novel, but the Surface Table never really found its reason for being. A few high-end restaurants turned one into a touchscreen menu, but it never ignited as a product. Still, it blazed a path for future touchscreen initiatives, even if we're not sorting our digital photos by swiping through a "puddle" of photos on our 90kg coffee tables as Microsoft hoped.



RASPBERRY PI

Unlike many of the iconic computers here, the Raspberry Pi was no looker. But that didn't stop you buying one or more of those little green boards, did it? Partly that's down to its price – a computer for \$50 is just too good to ignore. The Pi's sheer flexibility has seen it become the darling of coders, hobbyists and tinkerers all over the world. And if you'll forgive us a moment of sentimentality, it was a welcome echo of that 1980s micro era that got many of us involved with computers in the first place.

SAMSUNG CHROMEBOOK

In 2011, Google proudly announced the arrival of a revolutionary new type of laptop: the Chromebook. Acer and Samsung both launched products in June, but it was with more of a fizzle than a bang. Early Chromebooks were criticised for being slow, and it took a couple of iterations before they started to gain traction – in schools in particular. In 2021, Chromebooks actually outsold MacBooks. Now, Google is making a push into the business world on the basis that its secure, long-lasting and always-up-to-date Chromebooks are the perfect choice for people who have to work anywhere.

APPLE MACBOOK AIR

When Steve Jobs took the first ever MacBook Air out of a manila envelope in 2008, Apple had changed the computer industry once more. Even at its thickest point, the MacBook Air was thinner than even the slimmest Windows competitor, the Sony TZ series, as Jobs pointed out with a scarcely concealed smirk. It's a design that's served Apple for well over a decade and still doesn't look the least bit dated. Windows laptops now rival the MacBook Air for thinness, but none has matched the MacBook Air's legendary status.



DELL XPS 13

The moment we laid eyes on the XPS 13 at CES in 2012, we knew a rubicon had been crossed. This, at last, was a Windows laptop with enough style and panache to rival Apple. But it wasn't trying to mimic its fruity rival but do something on its own, squeezing a 13.3in panel into a chassis the size of a 12in laptop. With an SSD and one of Intel's fancy new Core processors, plus a screen protected by Gorilla Glass, the only downside was its price. What's most amazing is that with each successive year Dell has improved on the formula.

2008

2008

2011

2012

2012



LENOVO YOGA

Windows 8 had its problems, but one of the best things it did was inspire a range of new hardware form factors. None in that era was better than the Lenovo Yoga, so named for its ability to flap and fold into a variety of configurations: It folded flat against its base to form a (rather chunky) tablet; it could be stood in tent mode for watching movies on an aeroplane tray table; or it could be used as a conventional laptop. The Yoga brand lives on to this day, proving that this most flexible of laptop designs had iconic staying power.

GOOGLE PIXELBOOK

Google doesn't have much of a hardware pedigree, but the Google Pixelbook remains the best Chromebook ever made, five years after it first appeared. Its 2400 x 1600 display still looks sharp by today's standards, and the 3:2 aspect ratio was a welcome, sensible change at a time when widescreen laptops were in vogue. However, the standout feature of the Pixelbook was its keyboard: soft yet perfectly responsive, it's still one of the best keyboards we've seen on a laptop. The Pixelbook was a premium piece of hardware in a sea of cheap plastic rivals.



MICROSOFT SURFACE

Some argue that the Microsoft Surface isn't truly iconic. That it hasn't had a material effect on the design of computers since the launch of the ill-fated Surface RT in 2012. But we have one eye on the future when we say that its kickstand-based approach, together with a fully detachable keyboard, marked a radical departure from the conventional clamshell laptop and may yet become the dominant design for mobile computers. Or may not. But at least Microsoft dared to do something different.



APPLE iMAC M1

The iMac was the first Mac to be built from the M1 processor – the MacBook's and the Mac mini got a head start in 2020. However, the iMac was the first M1 machine to get a significant redesign, and it was an instant classic. Stupendously slender, it looks like a massive iPad attached to an angled frame. It retains the trademark iPad chin, and in a nod back to the first-ever Macs, it once again comes in a range of striking colours. Being M1 based, it's insanely powerful without ever making a whisper of noise. It's presence in electric blue form.



THE NEAR-ICONS

ACORN ATOM (1980)

The Atom was the predecessor to the BBC Micro, and with 2022 goggles on, looked much more stylish than its successor.

Neat fact: the manual for the computer was called *Atomic Theory and Practice*.

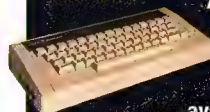
DRAGON 32 (1982)

We love the story of the Dragon 32 – a toy company deciding to build a computer is so mid-1980s – but it was basically a copy of the Tandy TRS-80.



ACORN ELECTRON (1983)

Acorn's attempts to build a cut-down BBC Micro was beset with difficulty, leading to long delays. By the time it was available, the demand had gone.



SINCLAIR QL (1984)

This could have been a Mac competitor, based around a 16-bit Motorola processor and with a brilliant multitasking OS. Plus a full suite of office software! But poor build quality and delays ultimately strangled the QL at birth.



ACORN ARCHIMEDES (1987)

Not iconic in terms of looks, but this was the first ARM-based computer – admittedly it's taken the world some time to catch up. It went on to be a stalwart in schools for the next decade.



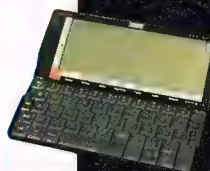
APPLE POWERBOOK (1991)

The predecessor to the MacBook Pro laid the foundations for Apple laptops. Thank the silicon gods that the trackball embedded beneath the keyboard was one of Apple's lesser copied innovations.



PSION SERIES 5 (1997)

Yes, yes, yes, the Series 5 was a PDA, but the World's Most Iconic PDAs would be a very short feature, so it earns an honourable mention here for that brilliant sliding clamshell design and the best mobile keyboard ever.



SONY VAIO X505 (2003)

Before the MacBook Air, there was the VAIO X505 – a ridiculously slender laptop given the components of the age. It was only 0.38in at its thinnest point, although the front-loaded keyboard was an acquired taste.

APPLE MAC MINI (2005)

Apple's slender slab of metal graces any desk it sits on (unlike the chunkier Mac Studio, which looks like a Mac mini that's been badly stretched in Photoshop). With M1 internals, it now has power and panache. ■



2012

2012

2017

2021

System News

Mark Williams puts on his 3D glasses to bask in a new era of chip design.



Mark Williams
Mark is an IT professional with a strong interest in voiding warranties.

Intel's 12th generation of Core CPUs was a big leap forward for the company, and was very much needed. After being on the back foot thanks to AMD's fast-progressing Ryzen CPU releases that stole Intel's much-coveted performance crown, it motivated Intel to redesign its CPU architecture and move to a Big. Little design to regain the ultimate performance crown.

With AMD's AM4 socket now sunsetting and about to be sent out to pasture later this year for the newer AM5 socket, AMD had

one last trick to play, and it's something that AMD talked about over four months ago, stacking a cache chiplet on top of a CPU to treble the available L3 cache. 3D V-Cache, as AMD calls it.

When AMD announce its first product

with 3D V-Cache, the Ryzen 7 5800X3D, it proudly proclaimed it would be the fastest gaming chip

"If you're building a new PC from scratch, getting the 5800X3D doesn't make much sense. You'll be buying into a dead platform with no upgrade path short of going for more cores for productivity."

SHOP TALK

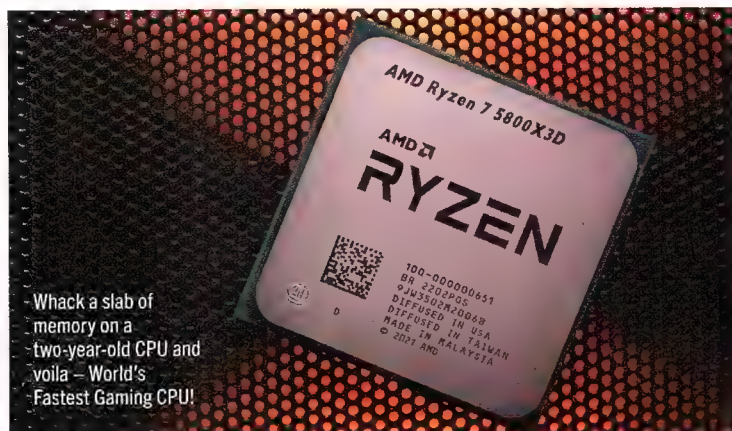
How popular have AMD's Ryzen 5800X3D and other newly launched Ryzen 5000 CPUs been since launch?

Jaimie, Leader Computers:

"Honestly we haven't seen stock yet. I don't expect to see them this financial year from what I have seen in the roadmap. We will be offering some very competitively priced gaming systems with the 5800X3D when they are available but so far, the stock availability at launch seems to be very limited.

There has definitely been some excitement from the enthusiast camp, and I can't wait to get my hands on one to play with!

Of the other new CPUs launched, the 5700X is a winner, high volumes of those selling and great bang for your buck. 4600G and 5600 have also been pretty popular."



Whack a slab of memory on a two-year-old CPU and voila – World's Fastest Gaming CPU!

on the market, comparing it directly with Intel's i7 12900K. Unfortunately for AMD, in the time it took to get the 5800X3D to market Intel launched the i7 12900KS which upped the stakes even higher.

Thankfully for AMD, reviews and benchmarks of the 5800X3D have held up well and indeed when averaged out over many game benchmarks it is fractionally faster than the 12900K by about one percent, with the 12900KS beating it again by a further one percent.

While all this is well and good for competition at the top end, one must look a little deeper to appreciate just how impressive the 5800X3D is. First, it's essentially a two-year-old CPU (5800X) that had to be downclocked by 200MHz at peak boost to cater for the voltage-sensitive cache chiplet atop the CPU. It also draws significantly less power than the hot and hungry 12900K – and especially the KS – and only costs \$650 versus \$850 or \$1,200 for the Intel parts.

There's also the fact that all this performance comes without the need for expensive DDR5, in fact you don't even need fast RAM at all to get the maximum performance (in games) as the cache is big enough to smooth that weakness out. DDR4000 versus DDR3200 memory shows almost no difference when gaming. This makes it the perfect upgrade for anyone on an AM4 platform with a pre-Ryzen 5000 series CPU with

older RAM.

The 5800X isn't for everyone of course. If you're building a new PC from scratch, getting the 5800X3D doesn't make much sense. You'll be buying into a dead platform with no upgrade path short of going for more cores for productivity. Intel's 12th Gen however, offers far superior multithreaded performance and a platform that will get at least one more CPU generation for upgrades, plus the benefits that new platform brings with faster memory and PCIe5.0 compatibility.

As a technology piece the Ryzen 7 5800X3D is an impressive product and if you're already on AM4 and focus much of your compute time on gaming it's a great bit of kit. For any other situation, it doesn't make a whole lot of sense, especially when the i5 12600KF can be had for just \$390 and has a performance deficit of less than four percent.

Much like the i7-5775C from 2015 which had a huge 128MB eDRAM on package that gave it a unique ability to fight far above its weight in gaming, the 5800X3D is playing the same tune and going forward AMD now has an extra feather in its cap to draw upon for future CPUs.

Given how much the V-Cache boosts gaming performance (and basically nothing else) we should expect to see more 3D V-Cache enabled products come to market when AM5 launches aimed squarely at gamers. There are exciting times ahead. ■

Market Watch

A sampling of PC systems available this month



CENTRE COM PANDORA

\$2,999 – tinyurl.com/APC508COM

This great-looking system uses a case that riffs on the iconic Lian LI O11 Dynamic. Peering inside you'll see six RGB fans that keep the chassis well ventilated, two of which cool the AIO radiator to keep the beastly Intel 12700K temperatures tamed.

Paired with an RTX 3070 Ti you're getting a lot of compute performance for your dollar. The motherboard, 750W PSU and 1TB of SSD storage are all adequate for the target audience, however, there is one glaring issue with the build, the memory. Sure, DDR5 is expensive at the moment, but it seems that to bring this build in on budget Centre Com decided to match the CPU with the slowest available RAM on the market and only provide one stick of it, reducing the CPU down to single-channel mode. This will leave performance on the floor and would be the first thing to look at when upgrading.

■ **CPU:** Intel Core i7-12700K; **Cooler:** SilverStone Permafrost PF240 ARGB AIO; **Motherboard:** MSI Pro Z690-A DDR5; **Graphics:** MSI GeForce RTX 3070 Ti Gaming X Trio 8GB; **Memory:** Adata 16GB DDR5 4800MHz; **Storage:** Kingston SKC2500M8 1TB M.2 NVMe PCIe SSD; **Power Supply:** Cooler Master MWE 750W; **Case:** Karuza Pandora.



MWAVE THERMALTAKE INFINITY XTREME

\$3,899 – tinyurl.com/APC508MWV

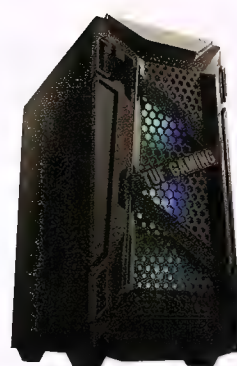
Ramping up the system price allows for some truly powerful parts. The RTX 3080 included here was impossible to find a few short months ago, but these are now plentiful and ready to drive your 144Hz+ 1440P or 4K monitors with ease.

The Ryzen 5800X – while adequate – isn't class-leading any more thanks to Intel's 12th Gen parts, but as long as you intend to keep the performance bottleneck on the GPU side with a high-resolution monitor with all the details cranked up in-game you won't notice a difference. If you want a 240Hz+ gaming experience though, perhaps look elsewhere.

The RAM is a good speed for this CPU and the 4TB hard drive is more generous than most other builds for capacity.

A solid system for those that prefer higher resolutions and visual fidelity over very high frame counts.

■ **CPU:** AMD Ryzen 7 5800X; **Cooler:** Thermaltake TH240 ARGB Sync Edition AIO Liquid Cooler; **Motherboard:** X570S WiFi; **Graphics:** GeForce RTX 3080 10GB; **Memory:** Thermaltake ToughRam Z-ONE RGB 32GB DDR4 3600MHz; **Storage:** 500GB M.2 NVMe SSD, 4TB SATA Hard Drive; **Power Supply:** Thermaltake Toughpower 750W; **Case:** Thermaltake H200 RGB.



AUSTIN COMPUTERS A28 V4 GAMING PERSEUS

\$4,599 – tinyurl.com/APC508AUC

Weighing in at \$4,600 this system should command the highest performance of all the systems this month, and while that technically might be true thanks to the 12-core 24-thread Ryzen 5900X which is about as strong as an Intel 12700K, the price doesn't seem to add up when compared to the better value Mwave system.

RAM is disappointing with it being slower at 3200MHz and half the capacity at 16GB. The hard drive is also half the capacity of the Mwave system too. The power supply is beefier here but that doesn't excuse the \$700 price markup, only \$100 of which would be the CPU.

An ok system that is definitely overpriced, best avoid this one until the price drops to at least \$4,000 flat.

■ **CPU:** AMD Ryzen 9 5900X; **Cooler:** Asus ROG Strix LC 240mm ARGB; **Motherboard:** Asus TUF Gaming X570-PLUS (WI-FI); **Graphics:** MSI RTX 3080 Gaming Z Trio 10G LHR; **Memory:** Kingston FURY Beast RGB 16GB 3200MHz DDR4; **Storage:** Samsung 970 Evo PLUS M.2 1TB PCIe SSD, Western Digital Blue 2TB; **Power Supply:** Cooler Master V 850W; **Case:** Asus TUF Gaming GT301 Black ATX.

SCORPTEC FROSTBITE

\$2,999 – tinyurl.com/APC508SCO

Coming in at the same price as the Centre Com system, the most glaring difference between the two is the step down in CPU SKU to the 12600KF, along with a switch to DDR4. Now, the difference between the two systems is arguably not that much when it comes to gaming, and the fact that this system has two sticks of RAM installed means the 12600KF can spread its wings better with dual-channel memory, which might actually mean it'll outperform the technically superior CPU in the other system just by virtue of not being starved for memory bandwidth.

This system also has 32GB of RAM and an extra 2TB of hard drive space, so unless you really need the extra threads for productivity tasks, this system is actually better balanced and more capacious.

■ **CPU:** Intel Core i5 12600KF; **Cooler:** Corsair iCue H100i Elite Capellix White AIO; **Motherboard:** Asus Prime Z690-P WiFi D4; **Graphics:** EVGA FTW3 Ultra GeForce RTX 3070 Ti 8GB; **Memory:** Corsair Vengeance LPX White 32GB 3200MHz DDR4; **Storage:** Samsung 970 EVO Plus 1TB M.2 SSD, Seagate BarraCuda 2TB HDD; **Power Supply:** Corsair RM750 750W; **Case:** Corsair iCue 220T RGB White ATX.



Blueprints

Value- and performance-driven hypothetical builds



"While some parts are pricier this month, budget GPUs continue to fall. Sales saw us nab an PowerColor Radeon RX 6600 XT Fighter 8GB for the AMD machine and an MSI Ventus RTX 3050 for the Intel."

BUDGET

A perfect balance between price and performance.

We've seen some price increases on components this issue. The Gigabyte B550 motherboard in the AMD build is listed at \$149 in our parts table, but you may be able to pick one up for less. Meanwhile, the Intel machine gets a new B660-chipset motherboard from MSI, the Pro B660-M, which is more expensive but offers a superior port selection to the B660 board from Asrock we used in previous issues. We're sticking with the processors found in both builds as there was little price fluctuation; we considered bringing additional integrated graphics to the Intel build, but the i5-12400F is cheaper than the UHD-equipped 12400, and testing has indicated a slightly better performance in single-core workloads.

While some parts are pricier this month, budget GPUs continue to fall. Sales saw us nab a PowerColor Radeon RX 6600 XT Fighter 8GB for the AMD machine and an MSI Ventus RTX 3050 for the Intel. Although these cards are still

pricey, we found the Radeon 6600 XT saved close to \$200 compared to just a month ago, while a softer but still appreciated saving of \$100 for the RTX 3050 compared to just a month ago – proof the GPU price drops are real. We added new memory to the AMD build, namely Corsair's Vengeance LPX at the budget build's usual 16GB, 3600MHz, CAS latency 16 specs.

Lastly, we looked into new drives across the board in our budget builds this month, but having added new SSDs to both machines last time, we were already pretty comfortable with the storage in these systems. Both SSDs and the WD Blue HDD we're using are very competitive in price, so we'll leave that hardware where it is. The Intel build's Team T-Force SSD dropped from \$129 last month, to just \$99 now, making it a very appealing choice for any build. Overall, we dropped the total cost of both budget machines by a small amount, which we're pleased with.

AMD INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	\$125
PSU	550W Corsair CV550 80+ Bronze	\$75
Mobo	Gigabyte B550 Aorus Elite AM4	\$149
CPU	AMD Ryzen 5 5600X	\$339
GPU	PowerColor Radeon RX 6600 XT Fighter 8GB NEW	\$549
RAM	16GB (2 x 8GB) Corsair Vengeance LPX CL16 @ 3600MHz NEW	\$110
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD	\$119
HDD	4TB WD Blue 5400 HDD	\$120
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$1,646

INTEL INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	\$125
PSU	550W Corsair CV550 80+ Bronze	\$75
Mobo	MSI Pro B660-M NEW	\$169
CPU	Intel Core i5-12400F	\$259
GPU	MSI Ventus GeForce RTX 3050 8GB NEW	\$449
RAM	16GB (2 x 8GB) Kingston Fury Renegade CL16 @ 3600MHz	\$139
SSD	500GB Team T-Force Cardea Graphene Z44L PCIe 4.0 M.2 SSD	\$99
HDD	4TB WD Blue 5400 HDD	\$120
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$1,495



MID-RANGE

A game-ready machine that can also handle demanding work.

We didn't change the power supplies found in our mid-range systems this month because the Nzxt C750 and EVGA SuperNova 750 GA remain the great value PSUs available at this wattage. Both systems keep their processors for now but the AMD build gets a new motherboard, the X570 Gaming X from Gigabyte, an absolute steal at \$229 (from Mwave). The Intel rig keeps its Asus Prime motherboard. For \$20 more, you can upgrade to the WiFi-enabled version of that Asus board; a potentially savvy decision for future-proofing your build even if you currently have easy Ethernet access.

Joining the AMD build's new arrivals this month is the Sapphire Pulse Radeon RX 6800 XT, cheaper than the previous 6800 XT we were

using last month. Prices of mid-to-high-end GPUs seem to be easing, though not as quickly as budget cards. The Intel system gets an RTX 3070 from EVGA, which is also \$250 cheaper than last month's Asus TUF mode.

We're making one last big change to our midrange builds in this issue: an upgrade to 32GB of total RAM. This will increase the total price, but falling GPU prices and greater performance from current-gen CPUs with access to more memory inspired us to make the switch. The AMD system gets the discounted Kingston Fury Renegade RGB, while the Intel system sticks with the Corsair Vengeance RGB RT (while upgrading to 16GB per stick, of course).

"While some parts are pricier this month, budget GPUs continue to fall. Sales saw us nab an PowerColor Radeon RX 6600 XT Fighter 8GB for the AMD machine and an MSI Ventus RTX 3050 for the Intel."

AMD INGREDIENTS

Part		Price
Case	Lian Li PC-O11-Dynamic	\$209
PSU	750W Nzxt C750 80+ Gold	\$129
Mobo	Gigabyte X570 Gaming X NEW	\$229
GPU	AMD Ryzen 7 5800X	\$499
Cooler	Corsair iCue H100i RGB Pro XT 240mm	\$169
GPU	Sapphire Pulse Radeon RX 6800 XT 16GB NEW	\$1,599
RAM	32GB (2 x 16GB) Kingston Fury Renegade RGB CL16 @ 3600MHz NEW	\$249
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	\$149
HDD	4TB WD Blue 5400 HDD	\$120
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$3,412

INTEL INGREDIENTS

Part		Price
Case	Lian Li PC-O11-Dynamic	\$209
PSU	750W EVGA SuperNova 750 GA 80+ Gold	\$149
Mobo	Asus Prime Z690-P LGA 1700	\$299
CPU	Intel Core i7-12700F	\$479
Cooler	Corsair iCue H100i RGB Pro XT 240mm	\$169
GPU	EVGA GeForce RTX 3070 Ti XC3 Ultra 8GB NEW	\$949
RAM	32GB (2 x 16GB) Corsair Vengeance RGB RT CL16 @ 3600MHz NEW	\$220
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	\$145
HDD	4TB WD Blue 5400 HDD	\$120
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$2,799



"Neither machine got a new GPU. Our Intel build EVGA GeForce RTX 3090 dropped by \$100, but the big win is the \$250 drop for the Asrock Radeon RX 6900 XT. The semiconductor shortage is finally easing, with graphics card stock coming home to roost."

TURBO

The maximum PC.

Our Intel 12900K saw a price hike this month, though not disastrously so. We're keeping both CPUs, although if you're willing to sacrifice integrated graphics you could save a few dollars by opting for the i9-12900KF in the Intel build.

The AMD Turbo build gets a new power supply and a new CPU cooler – the Cooler Master MWE 850 V2 and Nzxt Kraken X72, respectively. This PSU brings the AMD system up to 850W of total power, bringing it in line with its Intel counterpart. That Nzxt AIO is a good deal, though the LGA 1700-compatible MSI MAG AIO cooler we've added to the Intel rig this month is even cheaper. MSI is relatively new to the AIO cooling game, and wow has it worked to be competitive in the market.

Neither machine got a new GPU. Our Intel build EVGA GeForce RTX 3090 dropped by \$100, but the big win is the \$250 drop for the Asrock Radeon RX 6900 XT. The semiconductor shortage is finally easing, with graphics card stock

coming home to roost.

With our bump from 16GB to 32GB of RAM in the mid-range builds, it seemed appropriate to put those GPU savings to good use here too, so both systems are getting an upgrade to a hefty 64GB of memory. The AMD build sticks with DDR4, getting G.Skill's RGB-illuminated Trident Z Neo kit at 4,000MHz. The Intel system forgoes coloured LEDs in order to keep the price down with a Corsair Vengeance kit. DDR5 is still expensive, even more so when looking at 64GB kits, so stick to 32GB if you want to save some cash.

PCIe 4.0 SSDs at higher capacities are getting cheaper, with the excellent Samsung 980 Pro 1TB on sale for \$219. The AMD build gets this M.2 drive, while the Intel turbo system enjoys a WD Black SN850 to match its hard drive. While our doubled-up RAM raised the cost of these builds, savings elsewhere meant that the overall prices totals didn't increase much, so we'll consider that a win.

AMD INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	\$220
PSU	850W Cooler Master MWE V2 80+ Gold NEW	\$159
Mobo	Gigabyte X570 Aorus Elite WiFi	\$345
CPU	AMD Ryzen 9 5950X	\$819
Cooler	Nzxt Kraken X72 360mm NEW	\$229
GPU	Asrock Radeon RX 6900 XT Phantom Gaming D 16GB	\$1,899
RAM	64GB (2 x 32GB) G.Skill Ripjaws V DDR4 @ 4000MHz CL18	\$399
SSD	1TB Samsung 980 Pro M.2 PCIe 4.0 NEW	\$219
HDD	6TB WD Blue 5400 HDD	\$195
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$4,544

INTEL INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	\$220
PSU	850W Corsair RM850 80+ Gold	\$189
Mobo	MSI PRO Z690-A WiFi LGA1700	\$329
CPU	Intel Core i9-12900K	\$829
Cooler	MSI MAG CoreLiquid 360R V2 360mm NEW	\$159
GPU	EVGA GeForce RTX 3090 FTW3 Ultra Gaming 24GB	\$2,799
RAM	64GB (2 x 32GB) Corsair Vengeance DDR5 @ 5200MHz NEW	\$799
SSD	1TB WD Black SN850 M.2 PCIe 4.0 NEW	\$248
HDD	6TB WD Blue 5400 HDD	\$195
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	\$60
Total		\$5,827

The best as voted by Australians



Congratulations to the award-winning tech
brands that took out honours in the 13th annual
Mozo People's Choice Awards

TELEVISIONS

TCL, JVC, Hisense,
Sony, Samsung

HEADPHONES

Bose, Apple, Jabra,
Sennheiser, Anko,
Sony, Samsung

SMARTPHONES

Apple, Google Pixel
Oppo

mozo.com.au

QUICK TIPS

The problem solvers

The APC team field problems across the spectrum of devices and software.

Learn a new trick or fix you can use.

Strange BSODs

Ever since Windows 11 was announced, I've started experiencing the notorious Blue Screen of Death (BSOD) at least once a day. I'm still running Windows 10 Pro 64-bit and have kept up to date with Windows Updates. In fact, that's often when I get a BSOD crash – just checking for updates.

"Your BSODs won't be the result of some Microsoft conspiracy, Frank. It's likely to be a coincidence when the issue began, but you don't say what you've done to troubleshoot the problem"

Is this Microsoft's new policy to force us off Windows 10? According to Microsoft, my laptop will support Windows 11, so I assume it should continue to support Windows 10 until the Windows 10 end date.

I've thought of switching to Linux and even looked at Apple briefly. If I do switch, I don't want anything to do with Microsoft, but I can't find anything that works like Outlook, so I'm stuck.

Which Linux is Microsoft not involved in? I know you guys often recommend Ubuntu. Since I have Ubuntu on Windows, I'm assuming Microsoft is involved. Is this true? Can I extract myself from Microsoft operating systems? And can Linux

guarantee to stay up and running like real UNIX systems do? Or will I have to live with constant crashes?

In case these BSOD crashes have anything to do with hardware, I'm running an Intel Core i9-9900K CPU with 32GB RAM, 1TB internal drive plus 10TB external hard drive. Windows 10 Pro is version 21H2. I've also got an additional 8TB external hard drive for backup. I use Code42 CrashPlan for backups, both offsite and to my 8TB drive. I run a homegrown script to zip my script library weekly as a backup, which is then copied to my C: drive.

Please help me by explaining the direction you think I should go. Most of my customers run AIX, so I don't need Windows, but I would like to continue using Outlook.

Frank Posa

APC responds: Your BSODs won't be the result of some Microsoft conspiracy, Frank. It's likely to be a coincidence when the issue began, but you don't say what you've done to troubleshoot the problem. Without tackling the underlying cause, you will continue to be plagued by these BSODs.

Without knowing more about the errors you're getting, it's impossible to offer anything other than generic advice, such as

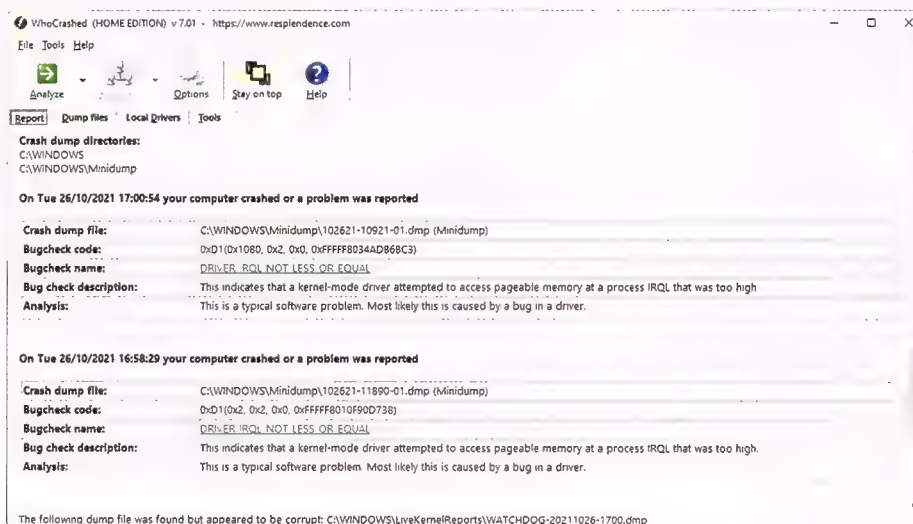
following the info in the Save Our Systems feature in our February issue, downloading and running the free version of the Windows Repair tool (www.tweaking.com) to perform basic system checks, including chkdsk on your hard drives and SFC on Windows system files. Also, test your RAM – a common cause of random BSODs – using Memtest86 (www.memtest86.com/memtest86.html) rather than the built-in Windows Memory Checker tool.

If all these check out, you'll need to find out more about the BSODs you're suffering. The solution here is to install the free version of WhoCrashed (www.resplendence.com/whocrashed), which will provide more detail about crashes, with the hope of identifying an underlying cause and possible solutions. Also, consider whether now is the time to bite the bullet and reinstall Windows from scratch to create a factory fresh, stable installation to work from going forward.

As for Microsoft's links to Ubuntu, consider it and Canonical (Ubuntu's developer) as frenemies, nothing more. Ubuntu isn't the only shell you can get for Windows; both Debian and Suse are also available, for example. We like Ubuntu because it's well supported and geared towards those with less experience using Linux – choose the LTS branch if you favour stability over new features. If you dislike Ubuntu's Gnome desktop, try an Ubuntu variant such as Mint (<https://linuxmint.com/>) or Elementary (<https://elementary.io/>). Create live media to explore each environment without committing to a full install.

Regarding the Outlook sticking point, if you're happy with Outlook's web-based version (<https://outlook.office.com>) then try a desktop wrapper such as Prospect Mail (<https://github.com/julian-alarcon/prospect-mail>). If you're looking to replicate the desktop version of Outlook, your biggest issue will be accessing an Exchange server. Both Evolution (<https://wiki>.

Use WhoCrashed to help troubleshoot BSODs.



gnome.org/Apps/Evolution) and **Thunderbird (www.thunderbird.net)** should work with Exchange servers, but if you're struggling, look at **DavMail (http://davmail.sourceforge.net/)**, which can act as an intermediary between Exchange and your Linux email app.

Lazesoft rescue issue

Lazesoft Recovery Suite was recommended in a previous issue, so I downloaded and installed the app on a USB flash drive – the problem is that it doesn't boot. Three other flash drives containing Windows 10, Windows 11, and my backup/restore/clone app all boot perfectly.

Lazesoft installed three folders and two files on my USB flash drive. The folders are: boot, efi, and sources, and the files are bootmgr, and bootmgr.efi.

I can't understand why the app won't boot. Any advice?

Jerry Bell

APC responds: We've tested the Lazesoft emergency boot disk extensively enough to know there's no known compatibility issue with it, despite the fact it hasn't been updated since Windows 11 was released. We had no problems creating the disk on our Windows 11 test system using the default settings, and it worked fine regardless of whether Secure Boot was enabled, and whether CSM was disabled.

We contacted Jerry and discovered he was able to get the rescue disk working on his Dell Inspiron 5585 laptop, but only after entering his BIOS and disabling both the Firmware TPM setting under Security and UEFI option under Boot. He was keen not to leave these settings like that, so reverted to their defaults. The key thing here is that he's found a way to get the Lazesoft rescue disk working should he need to use it.

A search online reveals that Dell's Inspiron laptops are notorious when it comes to getting certain types of boot disk to work. Many won't work at all with GPT-partitioned flash drives for example. If Jerry wanted to dig deeper, he could try creating the Lazesoft recovery disk as an ISO file, then using a tool like Rufus (<https://rufus.ie>) to create a bootable flash drive from it. Rufus allows you to control all aspects of the drive setup and formatting process – experiment with the partition scheme (MBR or GPT), target system (BIOS or UEFI), and file system

(choose FAT32) settings to see if you can get a bootable drive to work with your system without having to tweak the UEFI first.

Win11-compatible CPU

My wife uses an HP Pavilion 590-p0024 PC powered by an AMD Ryzen 3 2200G and 8GB RAM. Can I upgrade its processor to one that will support Windows 11, as this appears to be the only block? She uses this computer for working with MS Office apps and photos with ACDSee and feels left out when she sees my upgrade. I cannot convince her that upgrading will not gain that much for what she does.

Edmund 'Ted' Shaw

APC responds: The HP Pavilion in question is powered by a Sunflower motherboard, and a glance at its specifications online (<https://support.hp.com/us-en/document/c05939208>) reveals that TPM 2.0 support is built into the board. However, the stumbling block here was Microsoft's decision to exclude first-generation Ryzen chips (which include the Ryzen 3 2200G and Ryzen 5 2400G). This means only two processors on the Sunflower's compatibility list support Windows 11: the Ryzen 5-2600 and Ryzen 7-2700.

Although the Ryzen 7 has more cores and threads – 8 and 16 compared to 6 and 12 on the Ryzen 5 – the pair are closely matched, and indeed the Ryzen 5's slightly faster clock speed (3.4GHz to the Ryzen 7's 3.2GHz) gives it the edge in several benchmarks. At the time of writing, both are still available online, where the Ryzen 5 costs around \$250 and the Ryzen 7 around \$380. Ted will also need a discrete graphics card but plans to reuse an old ATI Radeon card. So long as it supports Windows Display Driver Model (WDDM) 2.0 or later, and DirectX 12 API or later, he should be fine.

Looking for inspiration

I've been wondering about programming: if there's a piece of the IT universe that I've never explored, this is it. Maybe it would allow me to restart from scratch and find new mysteries, connections, and discoveries behind those strings that, at the moment, are obscure to me. Do you think that would help?

There's a huge choice, so is there any direction you would suggest, especially now that you know my tastes? After all, I loved MS-DOS, and I still enjoy any moment I can put my hands on some CMD, PowerShell, Terminal, or similar window.

Nicola Di Pietro

APC responds: This was part of a longer letter from Nicola, who is looking to rekindle his love and enthusiasm for computers. As he identified programming as a potential outlet, APC recommends looking at the Raspberry Pi (www.raspberrypi.com) ecosystem. The Pi 400 combines computer and keyboard in a way not seen since the days of 16-bit machines and the barebones Pi 4 Model B lets you customize a PC from scratch.

More importantly, the Pi encourages you to try out new things – there are a myriad of hardware projects Nicola could explore. However, given his love of the command line and desire to program, perhaps the greatest gift would be an introduction to the world of Python (www.python.org), which underpins so many Pi projects (hardware and software). This has been selected by the Raspberry Pi Foundation as its primary language, so comes preinstalled with the Raspberry Pi OS. Visit <https://projects.raspberrypi.org/> to see if inspiration strikes. ■

Rekindle old computing magic with the Raspberry Pi.



WINDOWS

Advanced Windows 11 tips: Registry Editor

If you're looking to get more from your Windows 11 setup, you've come to the right place.

In this issue, we'll take a deep dive into your Windows Registry, which has been a vital component of Windows since the days of Windows 95. Basically, it's a glorified database stored across several files (known as 'hives') containing various configuration settings that cover all aspects of your PC: its hardware, the apps you've installed, and – of course – Windows itself.

To simplify matters, most Registry changes can be made via other Windows tools such as Settings or Device Manager, or within an application's own dialog boxes. However, other settings are hidden more deeply. Many Windows tweaking tools such as Ultimate Windows Tweaker (www.thewindowsclub.com) offer an easy way to make meaningful Registry changes without risk but doing so means you never understand what's going on

beneath the hood.

At some point, you'll need to access the Registry directly, whether it's to change an annoying feature or fix a problem, and that's where this tutorial comes in. We'll take you on a crash course of the Registry – how it works and how to edit it, plus reveal some useful tweaks that can make your Windows experience that bit better.

Start with a backup

Before you start making wholesale changes to the Registry, make sure you have a fallback. It's technically possible to bring down your entire Windows installation from a botched Registry setting, although in most cases, you'll merely break a specific part of your system or the application you're trying to tweak. While you can undo most Registry edits, it pays to have a failsafe in place – personal experience says you'll

thank us later.

Backups come in various shapes and sizes. If your drive image tool supports differential or, better still, incremental backups, then create your failsafe backup here. Macrium Reflect Free (www.macrium.com/reflectfree.aspx) supports the former.

You can also take a System Restore point, which backs up the Registry in its current state as well as other system files. Type 'system restore' into the Search panel and click 'Create a restore point'. Check System Restore is enabled for your system drive (click Configure if not) and then click Create to make a manual restore point. Give it a suitably descriptive name such as 'Pre-Registry tweaks' and click Create again [Image A].

If you run into problems, either roll back your drive image or return to the 'Create a Restore point' dialog and click System Restore... to undo your changes. In the unlikely event Windows won't boot, wait until it brings up the recovery screen, then choose Troubleshoot followed by Advanced and System Restore.

Access and navigate the Registry

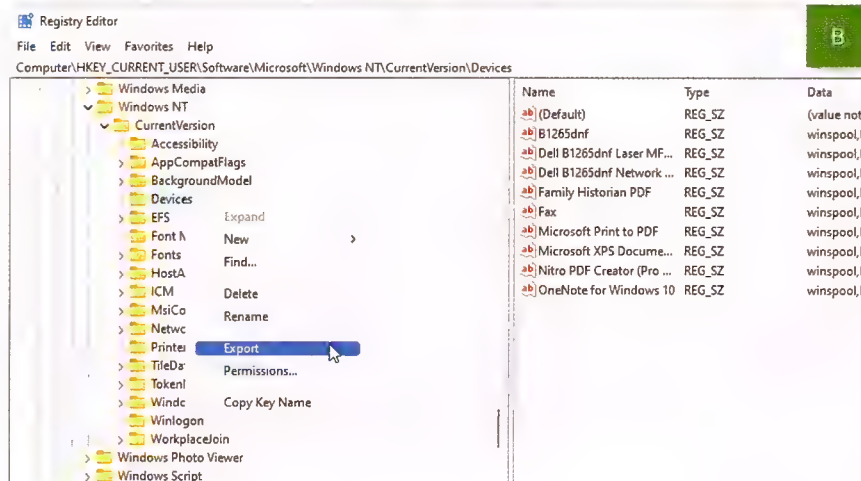
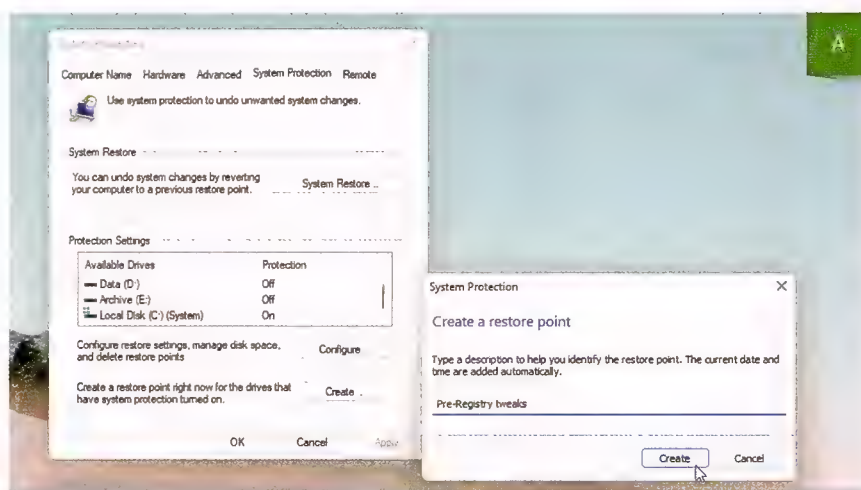
Windows offers its own built-in tool for accessing the Registry: Registry Editor (regedit.exe). It has all the tools you need to view and edit the Registry, although check the box over the page for a third-party alternative that makes Registry editing even simpler.

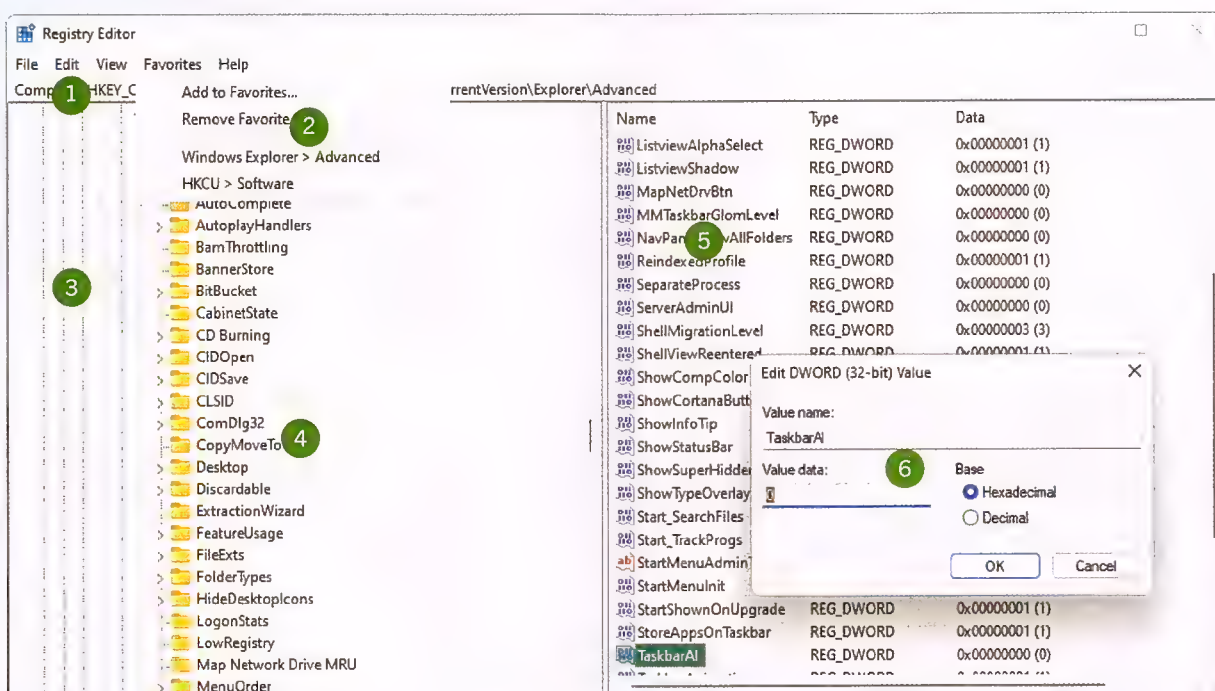
The fastest way to access Registry Editor is to press Win-R, type regedit and press Enter. Administrative access is required, so click Yes when prompted. You'll see a two-paned window appear – the annotation reveals the key components of regedit's user interface.

Registry Editor stores data as a series of values, organized into keys and subkeys as revealed in the Registry 101 box. To navigate, use the left-hand navigation pane like you would File Explorer: click a key to select it, or double-click a key to expand it and reveal any subkeys inside.

Select a key or subkey and you'll see a list of its associated values appear in the right-hand pane. You can edit or delete existing values and keys – be careful, as deleting a key destroys all its values too – or create new ones from scratch.

Given how easy this is to do, let's explore one final backup option: Registry





TOUR REGISTRY EDITOR

1. ADDRESS BAR

This recent addition to Registry Editor allows you to type or paste in Registry addresses to quickly jump to the specified subkey.

2. FAVORITES

Registry Editor allows you to store frequently accessed subkeys in its Favorites menu, giving you one-click access. Make sure you give them a suitably descriptive name.

3. NAVIGATION PANE

This left-hand pane allows you to move up and down through the various keys and subkeys that make up the Windows Registry.

4. SUBKEYS

A key or subkey that has a > next to the folder signifies that it contains further subkeys inside. Double-click on the arrow icon to open the subkey and reveal its contents.

5. REGISTRY VALUES

Each subkey contains one or more values that are used to record preferences and other settings. Values can contain text or numbers depending on their type.

6. EDIT SCREEN

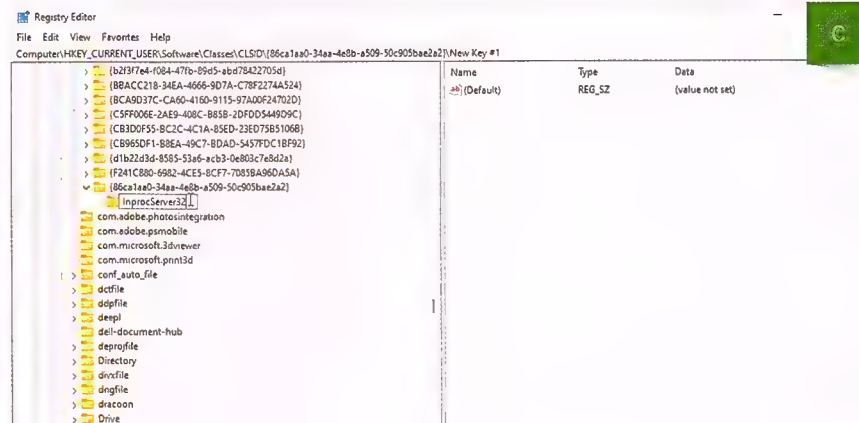
Double-click a value to edit it. String-based data contains a single editable field, while numerical values can be formatted in decimal or hexadecimal.

Editor itself. Regedit allows you to export individual keys (and their values) as text-based .REG files – simply right-click the target key or subkey in the left-hand pane and choose Export [Image B]. Give your backup a suitable name (and save it to your backup drive) before clicking Save.

You can restore a backup via File > Import inside Registry Editor or by simply double-clicking the .REG file and clicking Yes twice when prompted. These settings will overwrite whatever is current in the Registry (including any changes you've made), restoring things to how they were.

Your first Registry tweak

Let's start with a simple example of how you can change a Windows setting using the Registry. This first example merely requires you to create a single Registry value, then alter it. First, navigate to the following subkey in Registry Editor's



left-hand pane: HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer\Advanced.

You'll see a host of values appear on the right, all of which refer to some aspect of the Windows user interface. Choose Edit

> New > DWORD (32-bit) Value and name the new value TaskbarAI (that's a lowercase 'l' at the end, not a capital 'I').

As soon as the value is created, it will be assigned a value of 0, and you'll immediately see the taskbar icons align

REGISTRY 101

The Registry consists of a series of files known as 'hives', stored in two separate locations: Windows > System32 > Config for system-wide settings, and your personal User folder for settings associated with your user account.

Each hive consists of a different set of preferences and configuration data – for example, system-wide software settings are stored in a file called SOFTWARE. This information is organised into sub-folders or 'keys'. Each key contains one or more 'values' with associated 'value data', which are the configuration settings for your PC.

There are numerous types of value, depending on the data they contain. The most common include REG_DWORD values, which contain binary or hexadecimal numbers in 32-bit format (the 64-bit equivalent is REG_QWORD), and REG_SZ, which contains text such as drive labels, context-menu options, or the path to a particular folder or file on your hard drive.

Whenever Windows, a program, or hardware device needs certain settings or information, it consults the Registry for the specific values it needs, enabling it to function correctly. These keys, subkeys, and values are usually added when the software or hardware is first installed, and organized in a logical, accessible manner – for example, the HKEY_CURRENT_USER\SOFTWARE subkey contains many Windows and application settings.

to the left as per previous versions of Windows. Double-click the value and change it to 1, and they will return to being centrally aligned.

Remove the new context menu

Now for something more complicated. If you're fed up with having to click 'Show more options' whenever you right-click an item in File Explorer to bring up the classic context menu, you can disable this new, dumbed-down menu using the Registry.

First, navigate to the following key: HKEY_CURRENT_USER\Software\Classes\CLSID. Now right-click the CLSID subkey and choose New > Key from the pop-up context menu. Now comes the tricky bit, you need to rename this key to the following:

{86ca1aa0-34aa-4e8b-a509-50c905bae2a2}

Once done, select this newly created subkey, right-click it and choose New > Key again. Name this new subkey InprocServer32 [Image C] and then with InprocServer32 selected, double-click the solitary (Default) value in the right-hand pane. Simply click OK and its data will change from (value not set) to blank, which is enough to trigger the tweak.

Our previous Registry tweak was applied instantly, but others only come into effect when you restart Windows Explorer or, in some cases, your entire PC. The context menu tweak requires you to restart Windows Explorer, which is done via Task Manager: select Windows Explorer on the Processes tab (if it's not under Apps, you'll find it under Windows processes) and click the Restart button.

Once done, open a File Explorer window and right-click an item, you should now see the classic menu pops up immediately. To undo this tweak, simply delete the {86ca1aa0-34aa-4e8b-a509-50c905bae2a2} key you created, then restart Explorer again.

Go direct to a specific key

Navigating the Registry can be a time-consuming process as you move between keys, subkeys, and values. A recent addition to Registry Editor is the Address Bar, which works in a similar way to the folder path bar in File Explorer or the URL bar in your web browser. This allows you to jump directly to a specific subkey by typing in the address manually – for example: HKEY_LOCAL_MACHINE\SOFTWARE\Policies\Microsoft\Windows.

Don't worry about including the 'Computer\' bit, Registry Editor knows to add this. It's still quite a complex process, but thankfully you can use shortcuts in place of the lengthy HKEY_ part of the address: for example, use HKCU for HKEY_CURRENT_USER and HKLM for HKEY_LOCAL_MACHINE.

Even better, the Registry's Address bar supports copy and paste from other sources, so you can paste in full Registry addresses from text documents, websites, or wherever you happen to find them.

Make use of Favourites

Another way to speed up access to frequently accessed sub-keys is to use Regedit's Favorites feature. Select the key you want to access and choose Favourites > Add to Favorites. By default, the sub-key name is given as its entry, you can tweak this to make it easier to identify and click OK. In future, jump back to the key by selecting it from the Favorites menu [Image D].

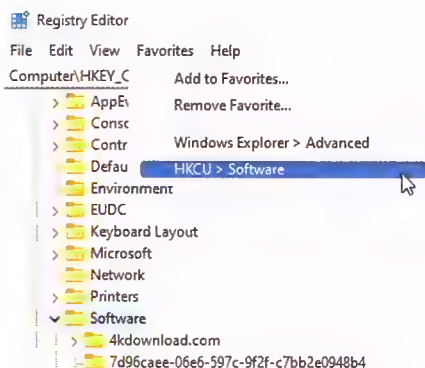
There are more useful shortcuts when navigating Registry Editor. Open a key containing dozens of sub-keys and you can quickly jump to one of these by typing the first two or three letters of its name. You can also use the cursor keys to navigate around the Registry, using the left arrow to collapse previously opened sub-keys.

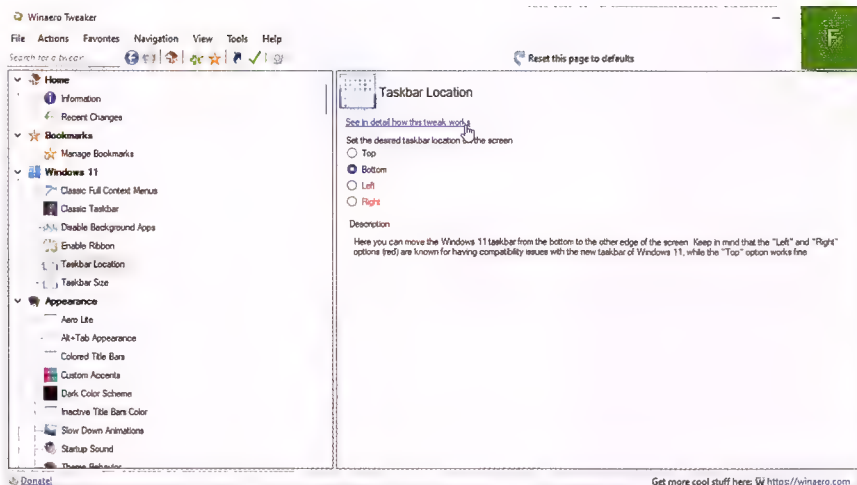
Time-saving tweaks

Other tweaks involve adding features to make options more accessible or removing unwanted steps in processes to speed things up. Let's start by speeding up application switching using the taskbar.

If an app has more than two windows open, you'll be forced to select your chosen window after clicking the app's taskbar icon, but you can save a click and simply restore the last active window, by navigating to HKCU\Software\Microsoft\Windows\CurrentVersion\Explorer\Advanced.

Make sure Advanced is selected and choose Edit > New > DWORD (32-bit) Value. Name this LastActiveClick, then





double-click it and change its value to 1. After restarting the Windows Explorer process, you should find clicking the program's taskbar icon always takes you back to the last window you'd opened.

Adding custom entries to the File Explorer context menu allows you to copy or move selected files to a specific folder from a single dialog. First, navigate to `HKCR\AllFilesystemObjects\shellex\ContextMenuHandlers`. Create a subkey inside this called Copy to Folder, then double-click its (Default) value and set it to `{C2FBB630-2971-11D1-A18C-00C04FD75D13}` before clicking OK.

Next, create a second subkey inside `ContextMenuHandlers` but this time, name it Move to Folder and change its (Default) value to `{C2FBB631-2971-11D1-A18C-00C04FD75D13}` – note the subtle difference between the two values. The change is immediate, and you'll find both options on the classic context menu (the one that appears when you select 'Show more options' if you haven't performed the tweak from step 4).

Make changes with batch scripts

Why get your hands messy with Registry Editor when you can make changes to the Registry directly from Notepad? By creating special script files using any text editor, then saving them with a .reg file extension you then simply double-click the .reg file to merge your changes into the Registry.

To do this, open a blank document in Notepad. Now type the following line at the top:

Windows Registry Editor Version 5.00

This identifies the script as a Registry file. Add a blank line beneath this, then type below that:

[Regpath]

Keep the square brackets but replace Regpath with the Registry key you wish to edit (any sub-keys that don't already exist will be automatically created, so you don't need manually create them in regedit first). Beneath this, type each of

the values you wish to create or modify on separate lines using the following syntax:

"ValueName"=Valuetype:Value

Valuetype should be ignored if the value is a string; otherwise, enter 'binary' for hexadecimal values, 'dword' for dword values. The example [Image E] creates a system profile you can apply when gaming to squeeze more performance out of your PC.

You can edit multiple Registry keys within a single document. Leave a blank line between each [Regpath] entry. Once done, choose File > Save, change 'Save as type:' to 'All Files' and remember to save your file with a .reg extension. Then back up and double-click the file to merge it into the Registry, or right-click and choose Edit to make further changes in the text editor.

Who needs gpedit.msc?

When surfing the net for useful tweaks – particularly when it comes to securing your PC – you'll often find a reference to gpedit.msc, or Group Policy Editor. This tool makes it easy to set various security and privacy policies in Windows, and

while it's aimed at enterprise and business users, it's often handy for us mere mortals too.

The only problem with gpedit.msc is that it's not available in Home editions of Windows. But don't worry, because Group Policy Editor is basically a neat front end for various Registry settings – it doesn't apply them directly, but they're eventually translated via special "local policy" files that are applied after a reboot. All you need to know is which tweak applies to which Registry setting, and thanks to a handy Excel file from Microsoft, you can do just that – download the Windows 11 21H2 ADMX spreadsheet.xlsx file from www.microsoft.com/en-us/download/details.aspx?id=103506 for the translation you need.

Get more tweaks

The internet is awash with Registry tweaks for you to try out, just make sure that you trust the website in question and have taken a recent backup before you begin.

Start your search with SpeedGuide's Gaming Tweaks (www.speedguide.net/articles/gaming-tweaks-5812). Tweaks from older versions of Windows should work in many cases, particularly those for Windows 10, but it's worth Googling the tweak in question with "Windows 11" to see if there are known compatibility issues.

As we stated, most tweak tools for your PC basically provide you with a user-friendly front end to tweak various Registry settings. One such tool, Winaero Tweaker (<https://winaero.com/winaero-apps/>), goes further than most in allowing you to understand what exactly it is the tweak in question does.

When selected, click 'See in detail how this tweak works' [Image F] and you'll be whisked to a page detailing what the tweak does and, if applicable, what Registry settings are changed. ■

REGEDIT ALTERNATIVES

If you plan to spend time tweaking Registry keys, you may become frustrated at some of Registry Editor's drawbacks. Spying an opportunity to fill those missing gaps, several third-party Registry editing tools have emerged.

One of the highest-rated is O&O RegEditor (www.oo-software.com/en/ooregeditor/), a freeware portable editor. Download the 1MB zip file and extract its contents, then double-click OOREgEdt.exe to launch it. You'll be prompted to make the app the default for opening .REG files – click 'No' for now until you're sure it's right for you.

You will see a summary of extra features O&O RegEditor offers: the Address bar keeps a history of previously visited subkeys for easy access, while the Favourites menu also makes a note of frequently used keys alongside any you create yourself (you can also import and export Favourites, unlike with Registry Editor).

In addition, the Search tool narrows your search to the currently selected key or subkey and lays out the results in a more logical way. O&O RegEditor also enables you to copy and move entire keys (sometimes, you'll need to duplicate keys between two locations, typically HKLM and HKCU).

WINDOWS

How to tame Windows Update

Fed up with continual updates and unexpected restarts? Darien Graham-Smith explains how to get along with Windows Update.

Windows Update is surely the least loved part of Windows. Since automatic updates were introduced back in the XP days, they've doubtless been blamed for millions of postponed presentations and lost essays, as the OS has repeatedly chosen the worst possible times to apply updates, or to ditch open documents and restart.

Unfortunately, a piece of software as complex and as fundamental as Windows does need periodic updates. With an estimated 1.5 billion people using it every day, bugs and security holes are going to be discovered that urgently need plugging.

Microsoft has another incentive to keep everyone current: Windows releases have a long lifespan, with Windows 8, 10 and 11 all still officially supported. That's a lot of different code streams to maintain, and the company certainly doesn't want to be supporting multiple sub-versions within those releases. It's in its interest to ensure that everyone moves up to the latest code as it becomes available – and since it controls the platform, that's what happens.

But while there's no getting away from Windows Update, you can learn to live with it. Once you understand what it's doing, and how to configure its behaviour to suit your needs, you can get the benefits of automatic updates with... well, perhaps not zero downsides, but a lot fewer than you might fear.

What's it sending me?

There are two main types of update that are ordinarily delivered by Windows Update: quality updates and feature updates. The former are the regular patches that help keep Windows running

smoothly, such as security enhancements or bug fixes. A quality update shouldn't have any visible effect on the way your computer works – except perhaps that it crashes less often, and doesn't get hijacked by hackers.

Feature updates are those that bring user-facing changes; for example, the upgrade from Windows 10 version 20H2 to 21H1 was categorised as a feature update as (among other changes) it plonked a new “News and Interests” widget on the taskbar.

To keep things efficient, Microsoft sometimes combines a set of updates into a single “cumulative update”. This keeps interruptions and reboot requirements to a minimum, and it's especially handy if you're setting up a new PC or working with one that's been offline for an extended period; it's quicker and neater than installing dozens of little individual packages.

The downside of cumulative updates is that you don't get to choose which elements you want to install – but that's somewhat moot as you're expected to accept and install every update that Microsoft deems applicable to your system. The only exception is a certain class of optional updates, which we'll discuss below.

When does it kick in?

The timing of Windows updates may seem maddeningly random, but there is a logic to it. The lynchpin of the update calendar is “Patch Tuesday” – the second Tuesday of every month. On this day, new quality updates are published by Microsoft, and by default all Windows machines install and download them automatically.

The original idea of the monthly schedule was to help corporate IT departments plan around expected updates, with the second Tuesday chosen so that staff wouldn't have to deal with updates during the first week of the month or on the first day of the week.

The timing doesn't just apply to businesses, however. Anyone running Windows 10 or 11 on their own computer will find that new updates are automatically downloaded and installed on Patch Tuesday – and not on other days, except in rare cases when a security issue is so dangerous it requires an urgent “out-of-band” update. For the most part, it's a very simple and predictable system.

Unfortunately, Microsoft has done a terrible job of explaining all of this. As a rule, updates are only automatically installed on Patch Tuesday, but they can become available at any time. Open up Windows Update and there's a fair chance you'll see an update ready for you to download and install right now. This creates the impression that Windows Update is continually lurking in the background, ready to surprise you with updates at some unexpected moment.

In fact, if you ignore any quality updates that are sitting there, nothing will happen: they'll simply be automatically installed on the next Patch Tuesday. Feature updates won't normally be installed at all, until you manually hit the button: they will only be installed automatically if that's required to bring an old, unsupported release of Windows up to date.

Can it respect my schedule?

While you can't move Patch Tuesday, you can tell your computer to ignore it – at least temporarily. Open up the Windows Update page in the Settings app and below the list of updates you'll see an option to pause updates. The standard delay is one week, but you can extend this to a maximum of 35 days. In Windows 10 this setting is found on the “Advanced options” page, while Windows 11 presents a handy drop-down menu that's right there on the main page.

Of course, pausing updates raises the risk that you'll miss out on something important: if you're suspending updates for an extended period, we recommend you try to find times when it's convenient to check for updates manually, and install any new ones that have become available. You'll need to click “Resume updates” to do this, but you can always pause updates

HOW DO I KNOW WHAT'S BEING INSTALLED ON MY COMPUTER?

Windows Update is designed to be as unintrusive as possible. Most likely you'll only know it's running at all because your computer automatically restarts once a month or so. For most of us that's fine – we don't need to be bothered with the full technical details of what's being patched, and we might not understand them anyway.

If you want to check what's been installed, however, you need to click the Update history link on the main Windows Update Settings page. The list itself isn't exactly informative – it mostly just says things such as “Update for Windows 11 for x64-based systems” – but you can click on the update title in Windows 10, or the “Learn more” link in Windows 11, to visit the web page on the Microsoft website that provides details of that particular update. These pages can be loaded with detail, to the extent that you may find you've gone from not enough information to way too much.

again afterwards – and reset the timer for another five weeks, should you so wish.

Can I permanently disable automatic updates?

If you hate interruptions, you might wish to turn off automatic updates altogether, and have Windows only check for updates when you tell it to. That's risky, though, and it's clearly not something Microsoft wants to encourage. If you're using the Home edition of Windows 10 or 11 then there's no official way to disable automatic updates; the closest you can get is to configure your home network as a metered connection, which will prevent the automatic downloading of all but the most critical updates.

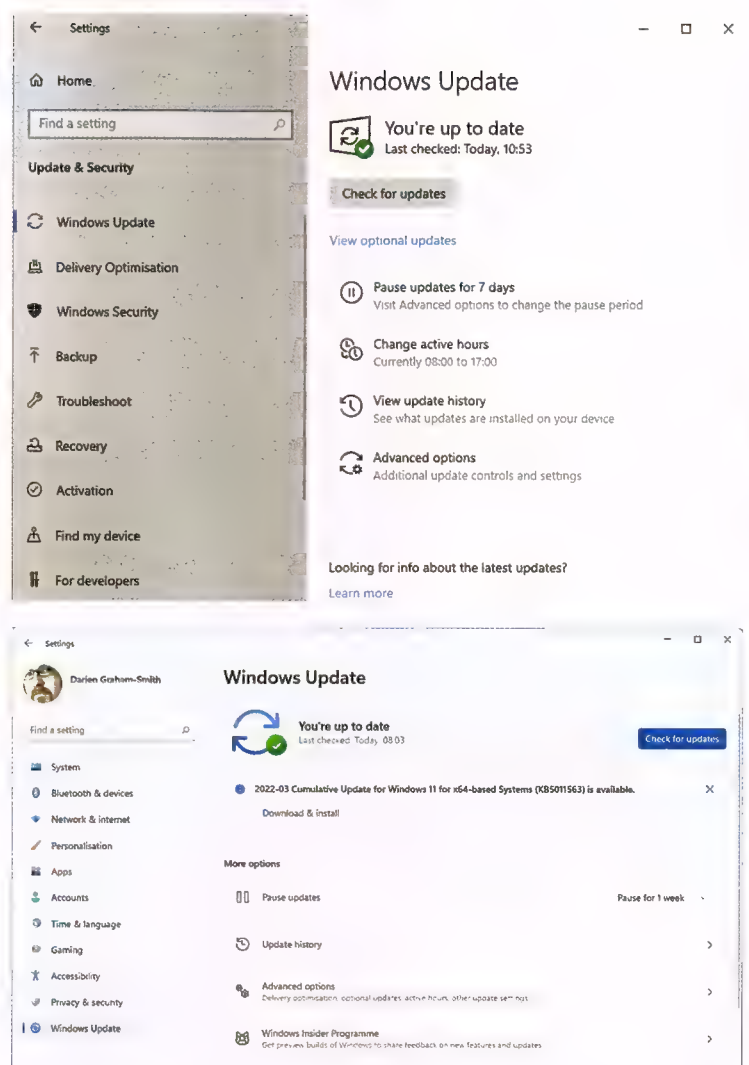
The Pro, Education and Enterprise editions of Windows do allow you to turn off automatic updates. However, this capability is intended for corporate networks where patch management is handled by a dedicated IT department, so rather than being conveniently exposed in the Settings app, the option is buried in the group policy editor.

To access it, open the Start menu and run `gpedit.msc`; once the Group Policy editor opens, navigate to Computer Configuration | Administrative Templates | Windows Components | Windows Update. Here you'll see an entry entitled "Configure Automatic Updates"; double-click on this and set it to Disabled to prevent automatic patching. Alternatively, you can set it to Enabled and choose from various custom behaviours, including automatically downloading new updates, but prompting you before installing them.

Can I stop it restarting my PC?

Let's be honest: the problem with Windows Update isn't the updates per se. It's when your computer decides to restart at an inconvenient moment, closing your open applications and potentially taking forever and a day to come back up.

But while we've all had that infuriating experience, Microsoft has been working to improve matters. In Windows 10 and 11, it's rare that an update will require a reboot, and when one is needed, the OS processes as much of the update as it can while the system



Left and Below: Windows Update provides a range of options that you can alter.

is running, so the restart should only take a few minutes at worst.

To further smooth things over, Windows 10 gained an Active Hours feature back in 2016. This attempts to work out when you're likely to be using your computer, and schedules updates for quiet times such as the middle of the night. You can check and change your Active Hours settings in the Settings app: in Windows 10 it's on the main Windows Update page, while in Windows 11 it's under "Advanced options".

Active Hours has its limitations. For one, Windows can't install updates if your computer is powered down or hibernating. If Windows Update doesn't manage to install an update within seven days of it becoming available, it will start pestering you during working hours to restart manually.

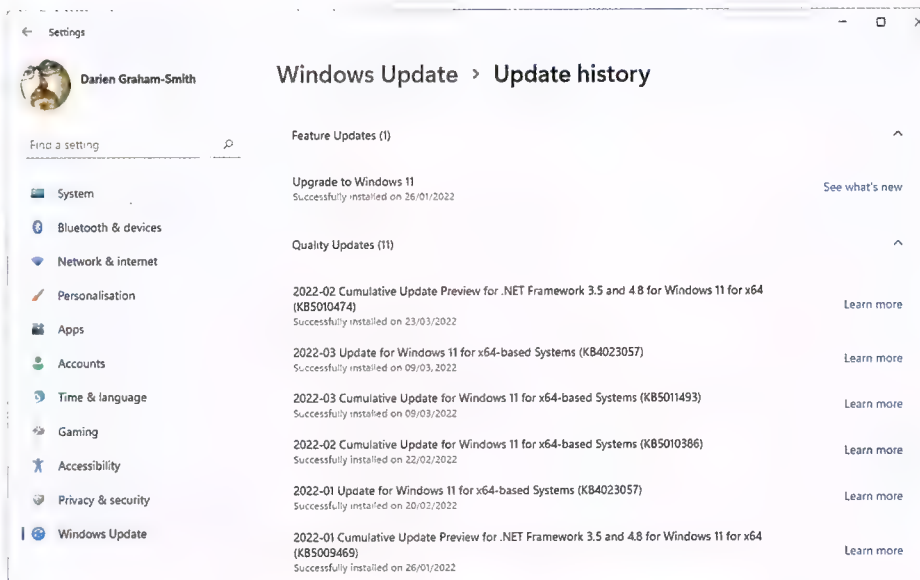
Conversely, when the system does manage to install an update overnight, it will reboot right away. This means you don't have to wait around in the morning, but it can

be disconcerting to find the documents and browser tabs you left open the previous evening are all gone. (A quick tip here: in most browsers, Shift-Ctrl-T will restore any tabs that were open when the app shut down – and you can press it multiple times to restore more than one window.)

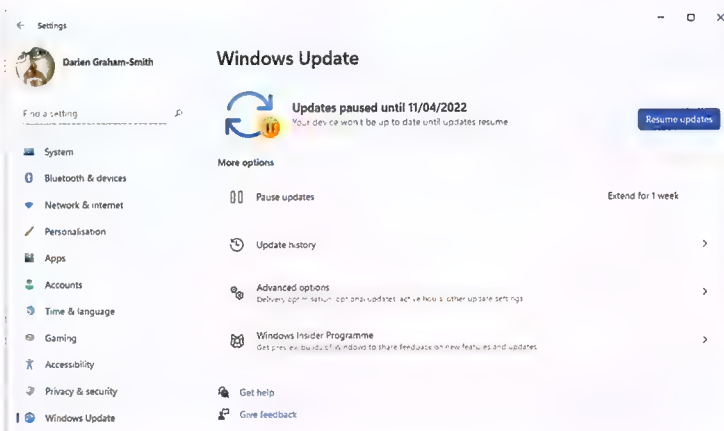
You'd really hope that Windows would warn you when an automatic restart is scheduled, but by default it doesn't. You can enable notifications by flicking the switch labelled "Notify

me when a restart is required to finish updating", which is located under "Advanced options" in both Windows 10 and 11. Windows still won't offer to postpone the reboot – the friendly "Restart now or later?" requester from Windows XP is long gone – but if you don't want

"If you hate interruptions, you might wish to turn off automatic updates altogether. That's risky, though"



Above: You can sometimes roll back a previously installed update. Right: Pause updates if you don't want to be disturbed.



to be disrupted you can go into the Windows Update settings and pause updates for up to five weeks, which will cancel the upcoming update.

If you want to entirely disable automatic restarts then you'll need to be using a Pro, Education or Enterprise edition of Windows. To do so, open the group policy editor and enable the "Configure Automatic Updates" policy as

mentioned above; then set it to option 4 ("Auto download and schedule the install"). Now find the policy in the same location entitled "No auto-restart with logged on users for scheduled automatic updates installations". Turn this on, then reboot one last time to refresh your settings; now, Windows won't restart again until you tell it to.

Do I have to install everything Microsoft sends me?

When you see an available update in the main Windows Update window, that means you're expected to install it, sooner or later. Declining is not an option. It is sometimes possible to roll back a previously installed update: click to view your update history, then click "Uninstall updates" to see updates that can be removed.

Note, however, that if you remove a quality update it's likely to be automatically reinstalled the next time Patch Tuesday rolls around.

Windows also offers a selection of optional updates, but these are tucked away on a separate page. You access it from the Windows Update page in the Settings app: in Windows 10 you'll see a link directly below the "Check for updates" button, while in Windows 11 it's under "Advanced options".

The list includes feature updates that haven't yet become mandatory, along with hardware drivers and firmware updates. You don't normally need to install these – Windows either has built-in drivers, or has already downloaded suitable software for each device. However, if a device has a problem, or is missing functionality, you can try these alternative packages to see if they help. It's a shot in the dark, but it doesn't hurt to have the option.

Can I control how Windows Update uses my internet connection?

Some quality updates are just a few megabytes in size; big feature packages may run into the gigabytes. If you have multiple Windows machines in your household you might be concerned about them all hammering your broadband line all at once, especially when Patch

ANTIVIRUS UPDATES

When we talk about security updates in Windows 10 and 11, we normally mean the OS updates that install themselves via Windows Update. Just to confuse the issue, the Windows Security subsystem downloads its antivirus updates via the same mechanism.

You may not have noticed these, as they're silently downloaded and installed on a daily basis. However, if you manually check for new updates, you'll sometimes see an available item called "Security Intelligence Update for Microsoft Defender Antivirus". New detections are released as soon as they're developed, so there may be several releases in a day that don't get picked up right away.

Although these downloads use the regular Windows Update service, they can't be postponed like other updates. Even if you tell Windows to pause updating for five weeks, it will continue to download and install the latest definitions. This shouldn't cause a problem, as updates are generally less than 2MB in size and can be installed entirely in the background, without interfering with your use of the computer.

If you really want to suspend antivirus updates, you can mark your network as metered, or forcibly stop the Windows Update service. We don't recommend this, though, as it means neither your core OS nor your virus protection will be protected against emerging threats.

CHANGING CHANNELS

This feature focuses on the “General Availability” update channel, which is the default for the vast majority of Windows systems. If you buy a new laptop with Windows preinstalled, or install the OS afresh yourself, you’ll be enrolled in the GA channel and will get all the updates that are, well, generally available.

There are other channels, however. For businesses that prioritise consistency over currency, Microsoft provides the Long-Term Servicing Channel, which receives a bare minimum of critical updates, with feature updates every two to three years and full support for a minimum of five years. However, LTSC

Tuesday happens to coincide with an important Champions’ League fixture.

You don’t need to worry: Windows 10 introduced a new peer-to-peer update system that keeps internet usage to a minimum. Once one Windows system has downloaded an update from Microsoft’s servers, it can share it with other clients on the same network, rather than each one having to fetch its own copy.

If you’re still concerned about bandwidth, you can throttle the whole Windows Update process, though the feature can be tricky to find. You need to go the Windows Update page in the Settings app, then click “Advanced options”, then click Delivery Optimisation, then click again on “Advanced options”. Now you’ll see the controls that let you set maximum upload and download speeds, either in absolute megabits per second or as a percentage of your available bandwidth.

Under Delivery Optimisation, you’ll also find an Activity monitor that lets you track where each machine has been getting its updates from and at what speed. If you don’t like what you see, you can turn off peer-to-peer update sharing – or, if you’re feeling philanthropic, you can volunteer to share your updates over the internet with other Windows users, to reduce the overall burden on the global infrastructure.

What else can Windows Update do for me?

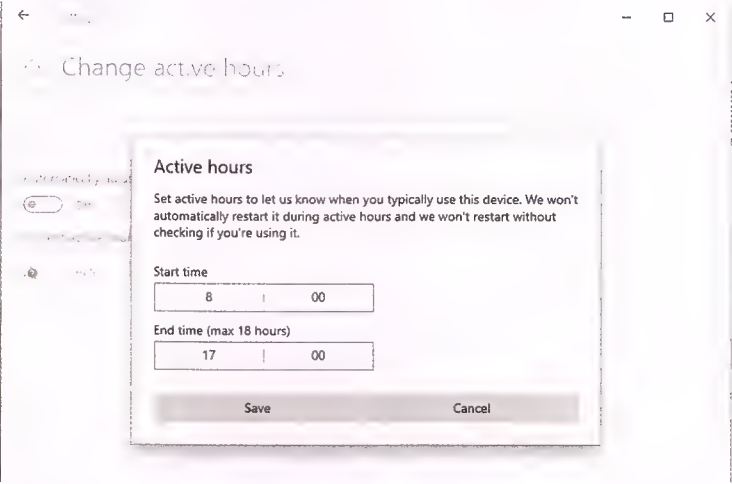
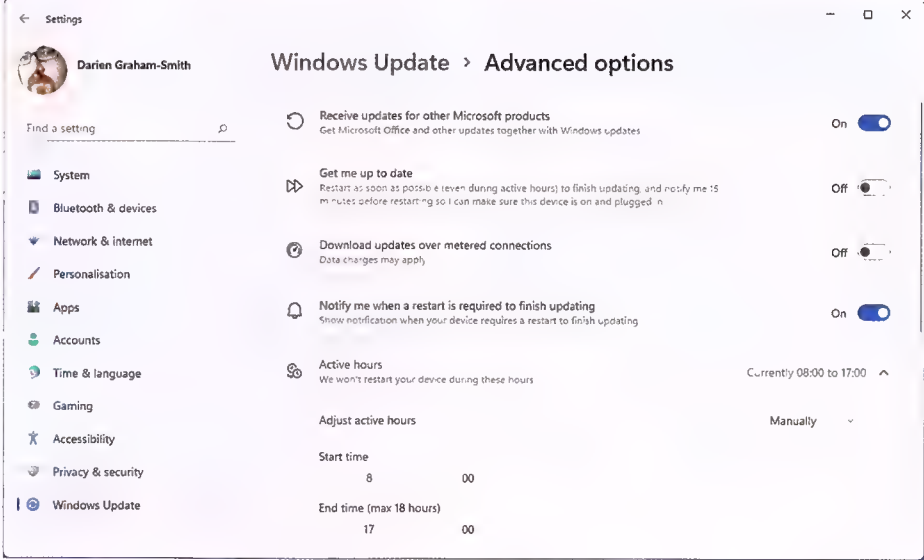
At the top of Windows Update’s Advanced options page you’ll see a switch enabling you to “receive updates for other Microsoft products”. By default it’s off, but turning it on will let Windows Update install application updates in the same way it handles core OS updates.

Frustratingly, there’s no list to be

builds of Windows can only be obtained via business licensing.

The Windows Insider programme gives you a choice of three additional channels that dole out the very latest features and fixes before they’re released to the public. The catch is that Insider updates haven’t been through the full testing procedure.

Depending on how dangerously you want to live, you can choose to join the Release Preview channel, to get a first look at upcoming major updates, or play more fast and loose on the Beta and Development channels. The latter is the best and fastest way to try out new ideas and features but, as Microsoft warns, you can expect “rough edges and low stability”.



Above: Advanced options let you receive updates for other Microsoft products. Right: Tell Windows when you’ll be using your computer.

found anywhere detailing which applications can be updated in this way. The important point is that it does apply to Microsoft Office. Turning on this feature ensures you’ll get the latest quality and feature updates to Word, Excel and so forth, along with your Windows updates, whether you’re on a Microsoft 365 subscription or using a standalone edition of the Office suite.

There’s just one caveat: if you

installed Office through the Microsoft Store, or accepted the trial installation that’s bundled with Windows 11, your updates aren’t handled by Windows Update, but through the Store’s own update system. In this case you can confirm automatic updates by opening the Store app, clicking on your user icon at the top right, selecting App settings and checking that “Update apps automatically” is enabled. ■

MAC OS

Manage macOS notifications

Stay focused and distraction-free while working on your Mac with Alex Blake



IT WILL TAKE
10 minutes

YOU WILL LEARN
How to tweak notifications and widgets to suit the way you work

YOU'LL NEED
macOS 12 or later

With so many apps loaded on to our devices, it's easy to get overwhelmed with the sheer number of notifications fighting for our attention. That's particularly true on the Mac, a device where so many of us do our daily work – and where we really need to concentrate the most.

Luckily, macOS Monterey has several built-in features that can

rein in the chaos and let you get back to the things that matter. From Focus mode to fine-grained notification controls, there are plenty of ways to get more control over the information thrown your way.

It's also worth looking at widgets, as these handy mini apps can display pertinent information right from the Notification Centre,

meaning you don't need to wade into each app every time you get an alert.

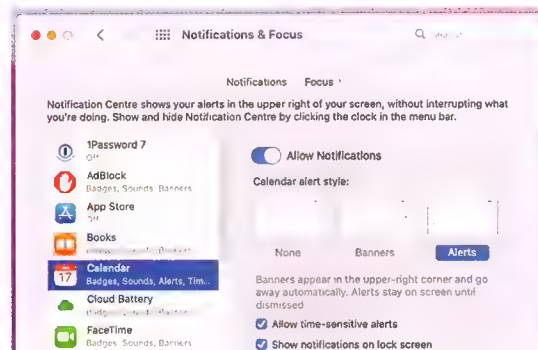
We've taken the plunge and explored each of these features to bring you the best in notification management. Put our tips into practice to restore some peace and quiet in your daily Mac life.

HOW TO MANAGE MACOS NOTIFICATIONS



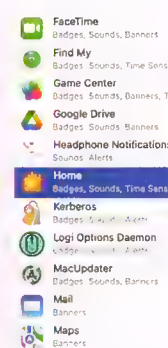
GENIUS TIP!

If you dismiss an alert by swiping it away, macOS stores it in the Notification Centre. You can take action on the notification from here.



1 APP-SPECIFIC ALERTS

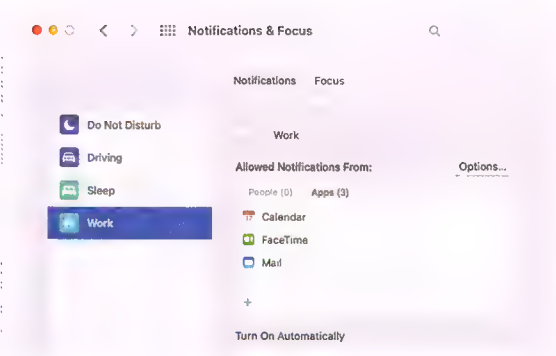
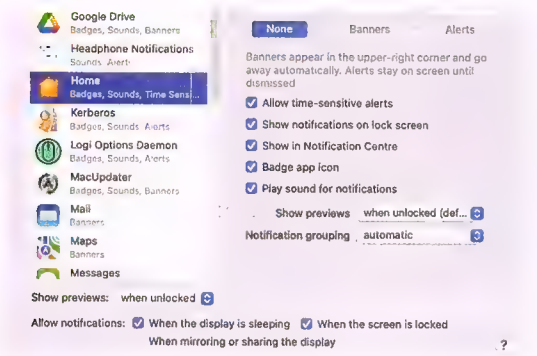
Click System Preferences > Notifications & Focus > Notifications, then choose an app. You can disable the app's notifications and change their style, or tweak other settings, like whether they are time-sensitive.



2 CRITICAL ALERTS

Some apps (such as Home) have an option for critical alerts. In the case of Home, this could mean sending you a notification from a smoke detector alarm even when you are using a Focus mode to block distractions.

CONTINUED... MANAGE MACOS NOTIFICATIONS

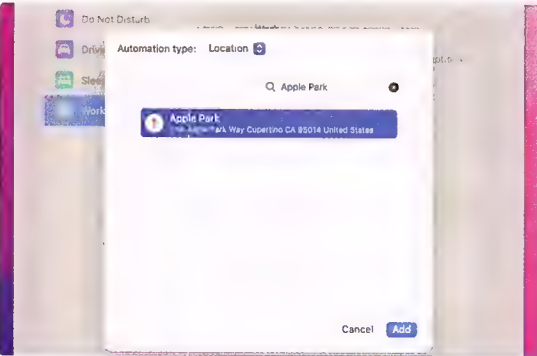


JARGON BUSTER

You can set important alerts (like imminent calendar events) to be time-sensitive. These are allowed through even when a Focus mode is active.

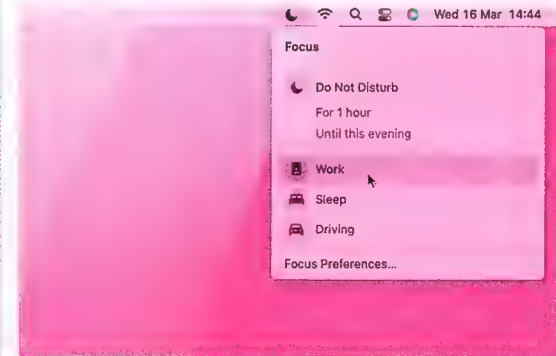
3 GENERAL OPTIONS

At the bottom of the settings pane are some general options. You can tell macOS when to show notification previews (only when unlocked, for example), whether to allow alerts when your display is sleeping, and more.



4 WORK FOCUS

Now click the Focus tab. We'll create a work Focus. Click the '+' in the bottom left and click Work. Under Allowed Notifications From, click Apps, then '+' and add some apps. Click People and choose who can contact you.

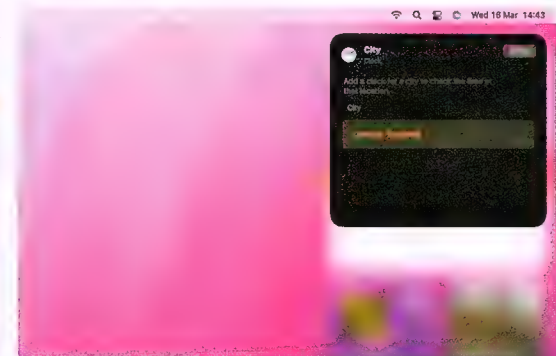
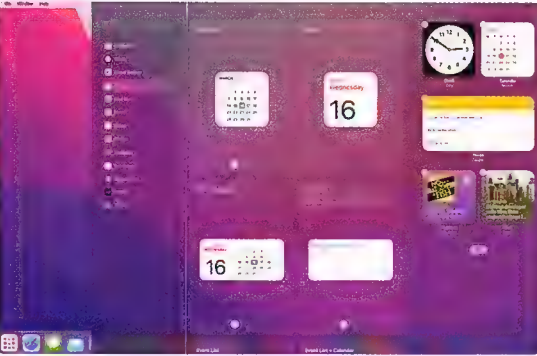


5 LOCATION ALERTS

Under Turn On Automatically, click '+', then Add Location-Based Automation. Enter your workplace's address, click the result, then click Add. Now the Focus mode will automatically turn on when you arrive at work.

6 MENU BAR ICON

Go to System Preferences > Dock & Menu Bar > Focus and tick Show in Menu Bar > Always. Now when you want to enable a Focus, just click the Focus icon in your menu bar and pick an option, like Work or Do Not Disturb.



GENIUS TIP!

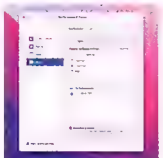
In Focus settings, the Share Focus Status option will let your contacts know you're busy if they message you while a Focus mode is active.

7 MAC WIDGETS

Now let's add some widgets. Click the date in your menu bar to open Notification Centre. At the bottom, click Edit Widgets. Now choose an app. Apps may offer different widgets, plus different sizes for each widget.

8 CUSTOMISE WIDGETS

Open Notification Centre and control-click a widget, then click Edit [App]. For the Clock app, for example, you can change which cities are displayed. You can also change the size of a widget by control-clicking it.



Discover the super-charged file manager

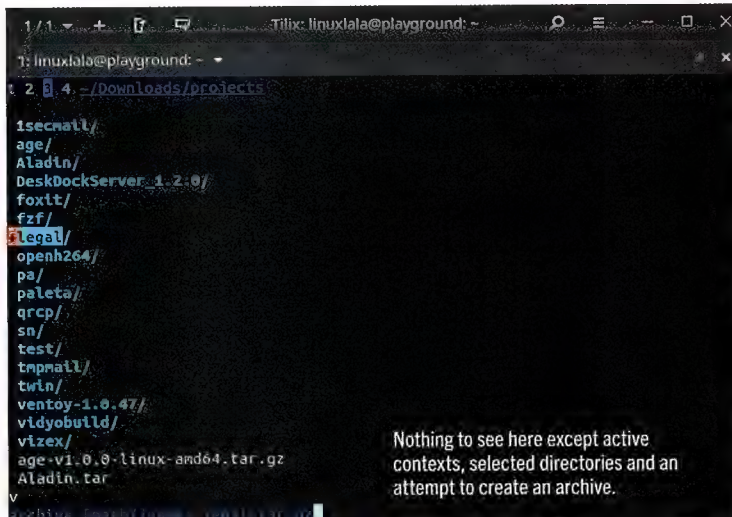
The problem of plenty has long plagued GUI managers where many tools offer similar features. Shashank Sharma recreates the situation on the CLI.

Previously we discussed the FFF file manager, which scoffs at traditional file managers in its appearance and functionality. Our tool of choice this issue, nnn, is cut from the same cloth. The project was originally forked from Noice, which is a small ncurses-based file manager, hence the name Noice is Not Noice (nnn), but the project has since dropped the acronym and now prefers to be known only as nnn, or n³.

"Unlike most other CLI tools, nnn doesn't have a man page. But you can learn all about working with the feature-rich file manager from the GitHub hosted wiki"

Many distributions carry nnn in their software repositories and the project's GitHub page (github.com/jarun/nnn) provides a list of these, and the version of nnn on offer.

Unfortunately, many distributions carry older versions of nnn in their repositories, but if you're running the latest releases of Debian 12, Fedora 34+, Arch, or Void Linux, you'll find the latest 4.4 release in the software repositories. Additionally, nnn utilises openSUSE's build service to provide installable binaries for distributions such as Fedora, Debian and Ubuntu. If you're either unwilling or unsure about



```

1/1 + - - - Tilix: linuxlala@playground: ~
2 4 - /Downloads/projects
1secmail/
age/
Aladin/
DeskDockServer-1.2.0/
foxtt/
fzf/
legal/
openh264/
pa/
paleta/
qrqp/
sn/
test/
tppmail/
twin/
ventoy-1.0.47/
vidyobuild/
vizex/
age-v1.0.0-linux-amd64.tar.gz
Aladin.tar
v
archive

```

Nothing to see here except active contexts, selected directories and an attempt to create an archive.

installing it from source, the project also provides a portable static binary, which enables you to use nnn without installation.

If you're running Ubuntu, grab the package for your distribution from the OBS service and then install it with the `sudo dpkg -i nnn_4.4-1_amd64.deb` command. Unlike most other CLI tools, nnn doesn't have a man page. But you can learn all about working with the feature-rich file manager from the GitHub hosted wiki (github.com/jarun/nnn/wiki), which is split into different sections such as Installation and Configuration.

Some would argue that a file manager's purpose is to help you

navigate the directory trees on your disk, and help you perform functions such as copying, moving, deleting or renaming files. Depending on the action in question, you might want to operate upon a single or multiple files. While nnn can do all these without a hitch, the quirky little tool has a lot more on offer.

Unfortunately, we're constrained by space to go over its entire feature list. Even better, you can also expand nnn with plugins, which are a mixture of useful and quirky. Whether it's reading ebooks, creating and performing checksums, viewing images or setting them as wallpapers,

WORKING WITH BOOKMARKS

Long-time readers will remember Buku, a useful directory bookmark utility we've discussed. You can find the same functionality in nnn, and can create bookmarks for frequently accessed directories. Bookmarks are defined using a `key_char:location` pair.

For instance, you can have D as a bookmark for ~/Downloads directory. To do this, run the `export NNN_BMS="D:~/Downloads"` command.

All `key_char:location` pairs must be separated by the `;` key. The command `export NNN_BMS="d:$HOME/downloads;p:~/Downloads/projects;t:/media/linuxlala/Stuffsies"` creates three bookmarks. You can view all the bookmarks from within nnn by pressing `?`. All user-created bookmarks are listed under the

BOOKMARKS heading.

You must add the export command to your `~/.bashrc` file, and remember to run the `source .bashrc` command every time you create a new bookmark, if you wish to retain it for future nnn sessions. To access a stored bookmark, press `b`, and nnn will display the available key characters used to create bookmarks. In our case, when we press `b` within a context, nnn shows 'd D' at the bottom of the screen. Press the key corresponding to the directory you wish to access.

In addition to creating permanent bookmarks, you can also set up a temporary bookmark, called pinning or marking a directory in nnn speak, by pressing `,` (comma). You can only pin one directory at a time. You can press `b` and then `,` to switch to a pinned directory.



GENIUS TIP!

You can use uppercase and lowercase letters to create bookmarks as well as number keys, apart from 1 through 4, which are configured for switching between different contexts.

splitting or joining files, creating an mp3 ringtone that you can use on your phone or integrating with fzf, all these tasks can be accomplished with nnn, if you install the right plugin. For most of the plugins, you'll also have to install their dependencies.

Out of the way basics!

When you first launch nnn with the nnn command, you'll immediately notice its spartan appearance. You're greeted with a list of all the directories in your current working directory, and little else. You can navigate through the screen using the arrow keys or if you're a devoted CLI junkie, using the Vim navigation. You can navigate into a directory by pressing either Enter or the right arrow key. You can similarly use the Backspace or the left arrow key to move to the parent directory.

When running nnn inside a desktop environment, the tool respects your file associations and open files in the default external application associated with the file type. For a list of all the keyboard shortcuts, press ?. You'll find the shortcuts are split into different categories such as Navigation, Filter & Prompt, Files and Misc.

You'll also notice that the nnn interface features four numbers at the top of the screen. These are called 'context' in nnn speak, but you can think of them as tabs. Each tab can be configured to default to different directories and settings. You can switch between the different contexts using the number keys 1 through 4. The currently active context is highlighted with a blue box. The file manager also identifies in-use contexts by underlying their respective number. If you've only just launched nnn, context 1 would be highlighted. Press 3 and you'll see what we're talking about.

Before you can exit nnn, all contexts must be closed. If you didn't use any contexts other than the default, pressing q will exit nnn. However, if you used the different contexts by pressing the number keys 1 through 4, then each time you press q, one context will close. That is, if you've used all the contexts, you must press q four times to exit nnn, but only twice if you only used two contexts. You can bypass this and immediately close nnn regardless of how many contexts you were working on by pressing Q, which makes nnn ask for confirmation to quit all

contexts at the bottom of the screen. Press y to exit.

File operations

The need and usefulness of contexts becomes clear when you have to move or copy files. You can have the source directory open in one context and the destination, which simplifies the process.

To select a file, navigate through the directory and then press the Space bar. You'll notice an orange-coloured + sign appear to the immediate left of the chosen file. Keep scrolling and selecting the files you want. Now use a different context to navigate to the destination directory and press p. This copies the selected files. If you prefer to move files instead, press v.

An interesting thing about this approach is that your selection can span multiple directories, across different contexts, and nnn has no problem performing any operation on the selected files as you see fit. For instance, from context 1, select two files from the ~/Documents directory, and then navigate to ~/Downloads and select another files. Now press 2, and in the second context navigate to ~/Pictures and select another five files. When you select the destination directory in context 3 and press p, nnn will create a neat copy of all the selected files.

You can similarly press x to delete the selected files. When deleting files, nnn will ask you to confirm the action. Notice the rm -rf hovered [Esc cancels] message at the bottom of the screen? You must press y to confirm delete, but note that this action isn't reversible. Files once deleted can't be recovered. We're not playing games here people!

Useful features

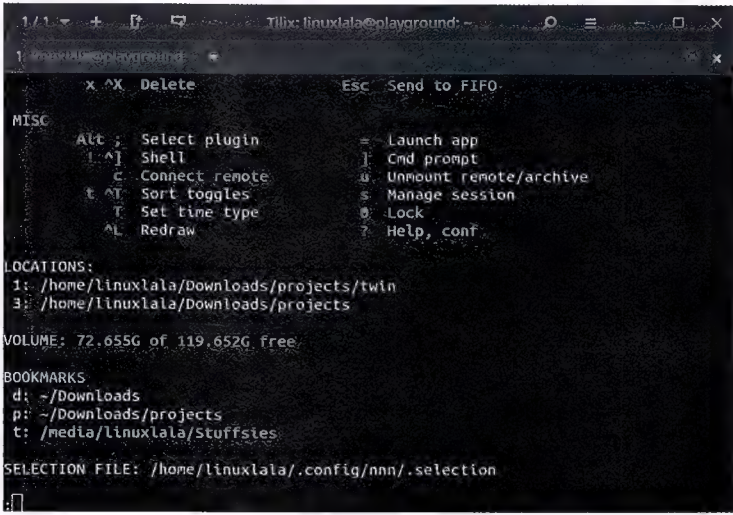
If you ever need to access the shell while working with nnn, you have two choices, You can either press the ! (exclamation key) to be dropped to the full-fledged shell, or press] to open a command-prompt. Toggle files as executable by selecting them, and then pressing *

In another departure from convention, nnn doesn't utilise config files. Instead, it supports a number of environment variables that can be used to perform myriad tasks. See the box (opposite) to learn how to use the NNN_BMS variable to create bookmarks with nnn.

There's still more that you can do with nnn, such as utilise the built-in filtering feature, which provides a search-as-you-type functionality to quickly locate the file or directory you're after.

But as the project lacks a man page, you should make it a point to thoroughly study the GitHub page, as well as the wiki to make sense of the vast feature set of nnn. Should you run into any troubles, you can open a new issue and report the problem, but chances are that a solution is already available, so search through the listed issues first. ■

"If you ever need to access the shell while working with nnn, you have two choices, You can either press the ! (exclamation key) to be dropped to the full-fledged shell, or press] to open a command-prompt. Toggle files as executable by selecting them, and then pressing *."



The ? key lists more than just keyboard shortcuts. It will also provide a list of all user-created shortcuts, as well as the current directory for each active context.

RASPBERRY PI

Using the Raspberry Pi as a daily driver

How capable is the Pi when it comes to carrying out day-to-day computing tasks?

Michael Reed powers down his x86 desktop to find out.

We've decided to see how viable a Raspberry Pi 400 is as a Linux-based 'daily driver' machine, and attempt to use it for day-to-day tasks in place of a standard desktop PC. The Pi 400 itself has similar specifications to a Raspberry Pi 4, but the whole thing is contained inside the keyboard unit. As part of the test, the bulk of this article was written on the Pi.

We'll start at the beginning, by looking at the device itself. Sat on a desk, the Pi looks like a white compact keyboard, but it's a tad heavier and fuller once you turn it over in your hands. Around the back, there are various connectors. From right to left these are: Gigabit

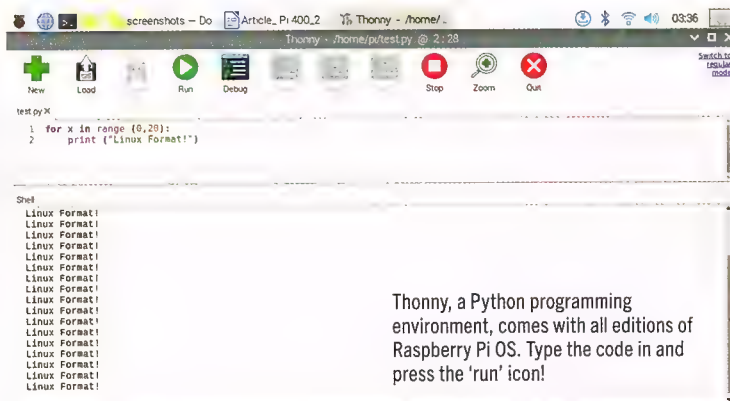
Ethernet, USB 2.0, two USB 3.0 sockets, USB C power, two micro HDMI sockets, a miniSD socket and finally a 40-pin Raspberry Pi GPIO header. Under the hood

the Pi 400 sports a quad-core ARM chip clocked at 1.8GHz and 4GB of RAM. Neither of these can be upgraded, and the RAM is shared between the CPU and GPU.

There are no analogue audio ins and outs, so we alternated between a USB audio adaptor (Lexicon Alpha) and some Bluetooth headphones. Both of these solutions worked flawlessly. The Pi 400 can also transmit audio through the HDMI connectors alongside the video data, if you have a suitable display.

"The Pi 400 itself has similar specifications to a Raspberry Pi 4, but the whole thing is contained inside the keyboard unit."

The Pi is capable of some simple gaming, but many of the games in the repository required a bit of work to get them going.



Thonny, a Python programming environment, comes with all editions of Raspberry Pi OS. Type the code in and press the 'run' icon!

Connecting it all up

For our purposes, we connected the official mouse and the power supply. One of the HDMI sockets was connected to a standard 22-inch 1080p monitor. For networking, we used the integrated Wi-Fi instead of the hardware Ethernet socket. In operation, the unit emits no sound because it's passively cooled. Despite this, at no time when we were using it did we feel that it was in danger of overheating, and we did some things that kept the CPU cores pretty loaded up.

Moving back to the exterior for a moment, the keyboard that's part of the Pi 400 consists of flat buttons rather than full-travel keys. This is the style employed by a lot of laptops these days, and you'll either enjoy using this style or you won't. You could put the unit on its side, next to the monitor, and use your own choice of USB keyboard, but that would defeat part of the object of using the Pi 400 as opposed to getting a (cheaper) Raspberry Pi 4.

With most PI OSes, you transfer the contents of an .img file on to an SD card and run the OS from there, in contrast to the typical desktop Linux procedure of installing the OS from one medium to the other. A Pi can run a number of operating systems, but we started our investigation with the supplied Raspberry Pi OS (formally known as Raspbian). This is a desktop operating system that's based on the ARM port of Debian. It's supplied with the machine, but we replaced it with the latest version. There's a larger version of the OS with all of the recommended applications, but we preferred to start off with the slimmer, standard version.

Raspberry Pi OS uses a lightweight window manager that's derived from the LXDE window manager. The default layout is a combined task switcher, application launcher and status area at the top of the screen. With standard Raspberry Pi OS, the application selection is bare-bones and the choices are lightweight. For example, PCMan is the file manager, and Geany and Mousepad are the supplied text editors.

Take it to the web!

The first essential tool that we needed to check out was the web browser, which in this case is Chromium, the open source version of the Google Chrome browser. Because it's a Debian-based OS, other browsers such as Firefox could also be installed.

Web browsing on a Pi 400 was a mixed bag compared to using a reasonably up-to-date desktop



computer or laptop. Some websites are lazily coded resource hogs that only give a good experience on fast hardware. The included build of Chromium seems efficient with a reasonably low footprint, but there's no getting around the fact that four 1.8GHz cores can only do so much when it comes to page rendering.

'Try it and see' is the best policy for seeing how the Pi 400 handles web-based work. Expect the same performance as a mid-level tablet. That said, compared to browsing on a tablet, the Pi does have all of the advantages of the full version of Chromium (or Firefox, among other options), a full keyboard along with whatever display you have connected to the Pi.

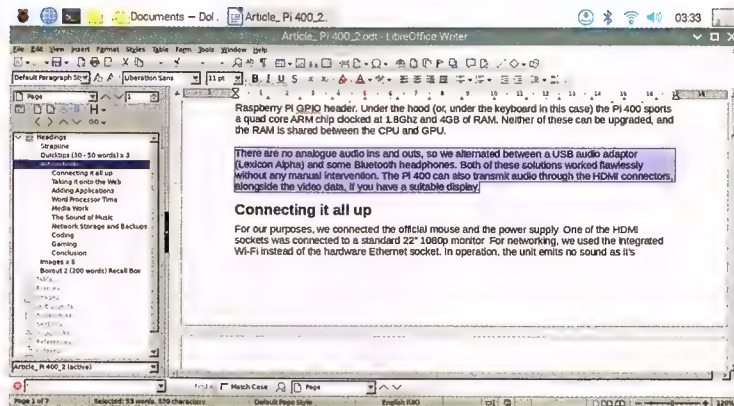
We were worried that the open-source nature of the OS and the supplied browser might be a problem when it came to viewing streaming content, but both Netflix and Amazon Prime played content without problems, even though the web interface was a bit sluggish.

Gmail was fine, as was Discord. Facebook also worked well. For YouTube, page layout when browsing for videos was on the slow side but playback was fine thanks to the hardware media acceleration of the Pi. Another thing that worked as it should was casting YouTube from Chromium on the Pi on to an Amazon Fire Stick, which we had installed on a nearby TV.

The performance on most sites was adequate, and we didn't run into any tasks that couldn't be carried out because we were using a Pi. This was, however, the main area of Pi usage where we started to miss a desktop PC.

Adding applications

Our next task was to install extra tools. Applications are installed via



the Add/Remove Software application, a GUI front-end that connects to the Debian ARM repositories. One small touch we liked here was that the categories in the package manager and the application launcher are the same and the icons match.

There's also a second package manager called Recommended Applications that offers a curated list of programs. These choices seem to correlate with applications that would have been installed if we'd chosen the larger Recommended Applications version of Raspberry Pi OS. Because the OS is based on Debian, apt can be used from the command line as usual.

Word processor time

We started writing this article in the word processor of Google Drive, but we found that performance left something to be desired. This was in keeping with our general experience with Google Drive, because it's a surprisingly demanding web application – even when run on a desktop computer. After a couple of days of sluggish and laggy word processing in Drive, we switched to LibreOffice, the first major application that we installed.

LibreOffice belongs to a class of classic Linux desktop applications that can now be considered fairly lightweight in terms of resource usage. In fact, an instance of Writer consumes a similar memory footprint to a single browser tab in Chromium, and Pi 400 handled it like a champ.

While staying within the realm of word processing, we soon hit upon the classic test of computer hardware compatibility: the dreaded world of printers. We needn't have worried, though, as the printer, a Canon MG 3050, was picked up and functional as soon as it was plugged into a USB port. This meant that we could print out a form and the envelope we needed using LibreOffice. For word processing using Writer, there wasn't much that a more powerful computer could have added.

The file manager that comes with Raspberry Pi OS is PCManFM. There's nothing wrong with this, but we decided to go full-fat in this area, and we installed Dolphin, the KDE file manager. This meant learning to live with a slight delay upon launching, but in use it ran at the same speed as PCManFM and with a comparable memory footprint.

LibreOffice Writer turned the Pi 400 into a perfectly usable word processing station.



GENIUS TIP!

SSH is easy to get going on the Pi by enabling it in the Raspberry Pi Configuration application. However, if you're using the Pi as a day-to-day computer and you need SSH access, we'd recommend disabling SSH password logins. Follow the instructions for either Debian or Ubuntu.

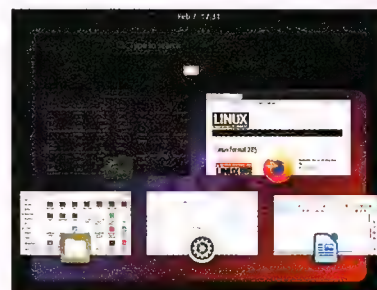
UBUNTU RASPBERRY PI EDITION

Canonical offers a Raspberry Pi build of Ubuntu Linux, but what's it like to run? In most respects, it's the standard Ubuntu experience. Most differences between Raspberry Pi OS and Ubuntu stem from the fact that Canonical don't seem to have made that many concessions to the more constrained specifications of the Pi, but bear in mind that with 4GB of shared memory, the Pi isn't constrained for light desktop use.

Having been in use for a few hours, with the official operating system and four

browser tabs in Chrome, two LibreOffice Writer documents and the Dolphin file manager, a total of 1GB of memory was used up. Under a similar load, in Ubuntu, 1.5GB was used up. Ubuntu took around 53 seconds to boot up, compared to around 30 seconds for boot up with Raspberry Pi OS. On Ubuntu, the stock Firefox seemed to run just as well as Chromium.

Overall, we were impressed, and for desktop/office use, Ubuntu might be just as good a fit as Raspberry Pi OS on the Pi 400.



The task switcher and launcher should be a fairly familiar scene to any user of Ubuntu. Most of the experience stayed fairly close to the standard Ubuntu one.



GENIUS TIP!

The official Raspberry Pi 400 kit might be worth considering. For an extra 30 pounds or so you get a shortish HDMI cable, a cute-looking official mouse and an official power supply that's probably a better option than a phone charger type of adaptor. The full-colour manual is excellent, too.

Media work

So, how can the media acceleration features and quad cores help matters when it comes to working with media editing? If you've ever tried to run the image editor GIMP on inadequate hardware, you'll know that it's a pain when brushes don't draw smoothly, for example, but we found that the Pi 400 handled all operations without any annoying delays. Obviously, if you have a modern desktop computer that's four times faster than the Pi 400, you'll get the results back four times faster when using the most complex filters. But when touching up or cropping and resizing images, GIMP ran very well on the Pi when working with images around 1080p resolution or so.

While playing around with GIMP, we faced a potential hardware compatibility hurdle by switching over to a drawing tablet for input. However, we needn't have worried because the HUION Inspiroy H950P (a fairly recent, entry-level model) worked flawlessly as soon as it was plugged into a free USB port.

Video editor OpenShot worked surprisingly well and it was possible to edit together a couple of 1080p video streams and do some titling.

Using an external DVD drive with the Pi also worked without problems, but we did opt to run it via a powered USB hub rather than plugging straight into the back. We had to manually add the libdvd-pkg package to play back commercial DVDs with it inside VLC, another application that worked absolutely fine on the Pi.

The sound of music

As a music workstation, the Pi 400 managed the basics. Most of the standard Linux music programs such as Rosegarden, LMMS,

File Edit Selection View Go Run Terminal Help

```

3 import './App.css';
4 var a = 1;
5
6 function addup()
7 {
8   var count = 0;
9   for (let x = 0; x < 100; x++)
10   {
11     count++;
12   }
13   return count;
14 }
15 function App() {
16   return (

```

Visual Studio Code ran very well. Extensions worked as they do on other OSes and installed themselves without any problems.

Qtractor and Ardour are present in the repository. We also tested the commercial Tracktion Waveform DAW (digital audio workstation), and this ran very well. As with most other things we tried plugging into the Pi 400, and the M-Audio Keyrig 49 (a fairly old USB MIDI keyboard) worked without any problems.

The music programs themselves all worked fine in terms of user interface responsiveness, but at all times the relatively modest CPU power of the Pi had to be taken into account when adding plug-ins. However, most music software can take advantage of the multiple cores, a point in the Pi 400's favour. A bigger problem was that few of the plug-ins that you might want to use have been ported to the ARM-equipped Pi platform.

Getting away from music for a moment, the de facto audio-editing application Audacity also ran extremely well. There are many intriguing scenarios for using a Pi like this as the controller of a hardware MIDI setup, and it can certainly handle basic DAW tasks for less-demanding projects.

Network storage and backups

We installed the operating system on to a 32GB SD card, a fairly typical setup for a machine of this type. This means that network connectivity is even more important than usual to add to the overall storage capacity. To get the setup working with the Pi, we had to install the Samba packages using apt. We could then browse to the NAS using the Dolphin file manager. However, we made it a permanent connection by adding the shared resource to /etc/fstab.

Once we had some network storage to play with, we set up a backup solution. We could have used rsync, but instead installed Vorta (the GUI frontend to the Borg backup system), and this ran perfectly. Backing up the home directory worked smoothly, and the CPU was at around 25 per cent while the backup was taking place, with foreground operations hardly affected.

Core coding

Encouraging people into programming has always been a core goal of the Raspberry Pi project. Various programming environments with an educational bent such as Scratch are supplied with the Recommended Applications version of the OS, and they're easily installed on to the standard edition using the Recommended Applications application. The Python programming language is fully installed by default, which is just as well because it can sometimes be a bit fiddly to set up on Linux.

We were surprised by how well Visual Studio Code ran, after we installed it manually from the website. Sure enough, as soon as we saved a source code file it displayed a recommended set of

The supplied build of Chromium had a surprisingly reasonable memory footprint, but it was a bit slow on some sites.

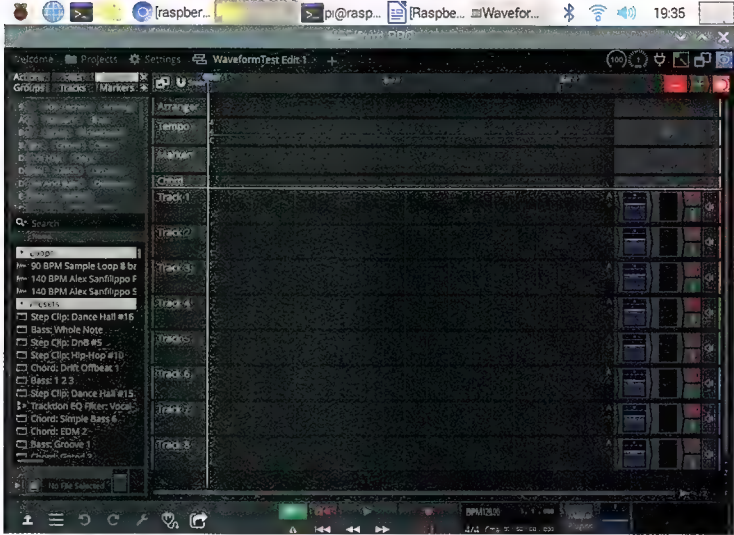
support packages for that programming language, and those extensions installed themselves as expected. There was some slight lag when suggestions popped up, but overall it ran very well, with all of the usual features. This is great news as it's one of the best programming editors around, and it's our recommendation for intermediate and advanced programmers using a Pi 400 or Pi 4.

One area where a Pi may even beat a desktop PC for programming work is when working with hardware projects. The Pi sports the standard 40-pin GPIO connector. This can be used for all sorts of hardware projects involving components like sensors and motors. There's also a massive maker community surrounding this. The snag is that there are some components that are physically oriented around the size and shape of a more typical Pi, so an adaptor might be needed.

Overall, the Raspberry Pi OS comes with some useful preconfigured tools for beginner programmers and for educational programming. If you were developing a rival to Facebook or a triple A game, you'd be better off with a more powerful computer though.

Playing games

We ran into a few problems when it came to 3D gaming on our Pi 400. As a result, many of the more advanced games in the standard repository didn't work properly or wouldn't run at all. This was the case under Raspberry Pi OS and Ubuntu when we tried open source 3D games such as OpenArena or Nexuiz. It was possible that they could be made to work by recompiling them or fettling the configuration in some way, but it looks like an area that the



distribution maintainers need to work on to make it a problem-free experience for non-experts. However, there's a massive collection of less-demanding classic Linux games such as *Lincity* and *Freeciv* in the repository and these worked perfectly well. Another factor working against the Pi as a games machine is the lack of commercial support.

We had much better luck when installing emulators of classic machines. Emulators for most common machines can be found in the repository, and other ones with Pi builds can be found by searching online. There are also entire distributions dedicated to running emulators (see box, below), and it's easy to switch SD cards around and reboot for this.

A perfectly baked Pi

After spending a week with the Pi 400, we found that it handled most applications perfectly well. Compatibility with external hardware was flawless with everything we tried, but we'd still recommend checking before buying when it comes to outfitting a Pi. We

also enjoyed the fact that it ran silently, and was power efficient. Under load, our Pi 400 consumed about 4W of power, about half that of a 60W equivalent household LED bulb. A typical desktop computer uses over 100W. Our 22-inch monitor used about 22W.

Looking at all of the jobs that we tried to carry out on the Pi, we didn't run into any areas where the 4GB of RAM was a problem. We felt that the package and distribution maintainers could have done a better job in making sure that games that use the 3D acceleration of the Pi 400 installed and ran with less user interaction.

Of course, a sub-\$200 system can't be expected to compete with a \$2,000 desktop PC in areas such as gaming or software development. With reasonable expectations in place, the Pi 400 can offer a lot of fun and can competently carry out most typical desktop tasks. Furthermore, anything that a normal computer can do on the web, the Pi 400 can probably do, but it ended up being the main area where we wished we had a bit more CPU horsepower at our fingertips. ■

Music programs such as Traktion Waveform were usable. The UIs worked fine, but we had to keep our plug-in use down a bit.



GENIUS TIP!

You can access network shares to increase your storage beyond what's possible on a humble SD card. Of course, you can also use one of the Pi 400's USB slots to access an external hard drive, giving some extra, fast local storage.

RECALBOX VERSUS RETROPIE

We tried two Pi distributions with a similar purpose: to boot into a menu-driven graphical environment that gives easy access to installed emulators and games. Recalbox was easier to set up. In contrast, we had to resort to the command line while setting up RetroPie.

Once it was up and running, we were impressed with Recalbox's overall aesthetic. As you move between console and computer emulators, you're met with

illustrations of the machine with some information about its specs, while charming chiptune music plays. Recalbox also came with some games already installed. Once a game is launched, it runs inside a faux CRT monitor border with a screen filter applied for the authentic retro look.

The emulators themselves were similar, and the Pi 400 could handle most 2D machines such as the Mega Drive and the SNES with ease.

RetroPie is a bit more bare-boned when it comes to looks. However, it's more extensible and configurable because it's much closer to a normal Linux distribution beneath the GUI.

Some might be willing to put in the effort to work with RetroPie, whereas others might prefer the overall look and ease of use that Recalbox offers.

Tech that changed Australia (and the world) — Part 2

As Australia's tech industry prepared for WWII, British and Australian scientists were achieving a momentous breakthrough that's still powering on today. Darren Yates explains.

It's unlikely the Australian government knew at the time how important this factory would become, but it must have been at least relieved when the Amalgamated Wireless Australasia (AWA) and Radio Corporation of America (RCA) joint-venture to make radio valves in Australia became a reality in 1932. Events during the 1930s made it clear war clouds were gathering

and in the event of war, Australia couldn't guarantee the supply of the overseas technology components it now relied on.

"The resonant-cavity magnetron was one of most revolutionary inventions of the war and helped tip the balance in favour of the Allies."

Made in Australia

The first Amalgamated

Wireless Valve (AWV) factory in Ashfield in Sydney's inner west began production in 1933, delivering over 350,000 valves the following year. By 1937, that number had ballooned to 750,000 and Dutch giant Philips also opened a valve factory in Sydney that year.

But importantly, Australia had also begun local research into valve design and within two years, AWV had developed new, more power-efficient valves specifically for battery-powered portable communications. As a result, many of those valves made in 1937 were



Workers at the Amalgamated Wireless Valve factory in Ashfield, Sydney in 1936.

also Australian-designed.

It was a good thing, too, for events in Europe were descending towards war and the U.K. had already begun preparing.

As the secret 'Chain Home' radio-direction and ranging network – what we now call 'radar' – grew along England's south-eastern coastline in 1937, Australian physicist (later Sir) Mark Oliphant, a graduate of the University of Adelaide some 15 years earlier, had risen through the academic ranks to become

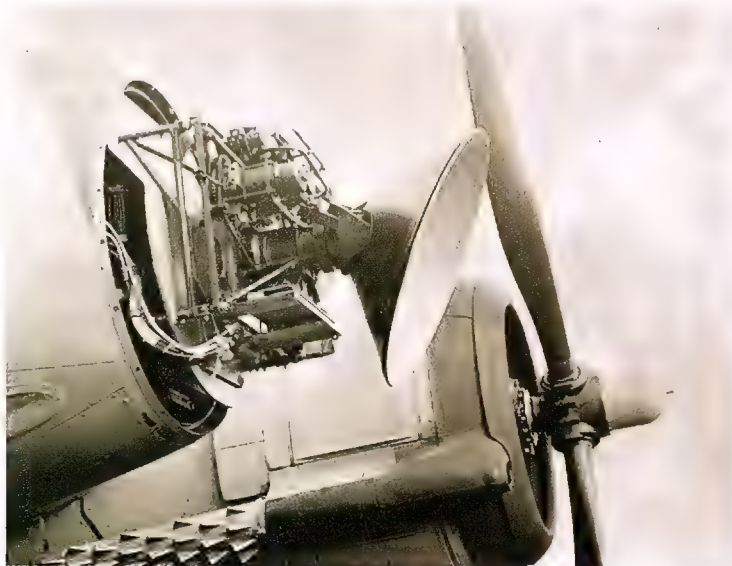
Professor of Physics at the University of Birmingham.

War Effort

David Mellor's official war history (Volume V – The Role of Science and Industry, Chapter 9) records the 1930s' Great Depression had a damaging effect on technical education and training in Australia. By 1938, not only were Australians training in technical skills at half the rate of the U.K., we also lacked sufficient teachers, buildings and equipment to do



Australian physicist Mark Oliphant in 1939.



Airborne microwave radar inside a Bristol Beaufighter aircraft during World War II.

the job – and time was indeed fast running out.

Australia's support of the U.K.'s declaration of war against Germany for its invasion of Poland came on September 3, 1939 and had a transforming effect on the local tech industry. As governments addressed the skills shortages, Australia's tech start-ups, such as Airzone, Breville, Healing and Kriesler, switched from making radios to tech aiding the war effort – Airzone made test instruments and early sonar units to detect submarines, Breville manufactured mine-detectors, Healing built direction-finding gear, Kriesler made communications equipment for the Royal Australian Air Force.

As Australian consumer-tech brands switched their focus to war-time needs, so, too, did the Australian scientific community – but it wasn't all 'smooth sailing'. Author David Mellor records in Chapter 3 that frustration was rife amongst scientists working outside government establishments early in the war, as they battled poor organisation and duplication of research. Meanwhile, one Australian scientist was about to lead ground-breaking research in the U.K.

Radio-Direction and Ranging

The U.K.'s Chain Home radar network was fully operational by the beginning of war in 1939. This network of radio-transmitters and receivers sent out 100,000-watt pulses of 30MHz radiowaves and listened for return-echoes indicating approaching aircraft. However, at this 30MHz frequency, radiowaves have a repeating cycle or 'wavelength' of 10-metres – this not only rendered radar less-sensitive, but its large antenna masts were an obvious target and prevented more portable use. The need for a smaller radar system – one that could not only see the small conning tower of a submarine, but also fit inside an aircraft nosecone – attracted interest at the highest level.

The British Admiralty reportedly contacted Mark Oliphant at Birmingham in 1939 about creating a source of radio 'microwaves', waves with a length of just 10-centimetres. At the time, one of two devices known to produce microwaves was the 'klystron', a specialised valve or 'vacuum tube' developed at

Stanford University in 1937, but it did so at only a tiny fraction of the power required. Nevertheless, Oliphant pressed on, looking to improve the Klystron's output. Needing receivers, also, to pick up the reflected microwave signals, Oliphant put two of his lab researchers, John Randall and Harry Boot, to work on the problem. However, despite the group's work resulting in an improved Klystron delivering 400-watts of output, neither the Klystron nor the initial efforts of Randall and Boot produced microwave oscillations at anywhere near the power required.

Slots and holes

Hitting a dead-end, Randall and Boot turned their attention to the 'split-anode magnetron', the other type of thermionic valve capable of generating microwave oscillations, but also only at 'vanishingly small' power and far too inefficient for war-time use.

Borrowing ideas from both the split-anode magnetron and the klystron, they invented a radical new thermionic valve design combining magnetic and electric fields. The workings consisted of a cylindrical copper block featuring a series of interconnecting slots and holes or 'cavities'. The belief was electrons would resonate around the cavities, creating the required oscillations. Within three months and with Oliphant sourcing extra funding, Randall and Boot had a prototype and on February 21, 1940, set up a test circuit, with a car headlamp to indicate oscillation power. As they applied the high-voltage power, they saw signs of oscillation almost immediately. Raising the voltage further, the headlamp quickly burned out. The device was producing more than 400-watts at first attempt.

However, the big question was the output wavelength – was it 10-centimetres? To find out, they connected the output to a 'Lecher line' – two parallel wires, along which a small lightbulb was run by-hand. The oscillation energy appeared along the wires as 'standing waves' with the lightbulb alternately going bright and dark as it ran along. By measuring the distance between alternate light peaks, they could determine the oscillation wavelength. They measured 9.8-centimetres – the new 'resonant-cavity magnetron' was a success.



A week later, 400-watts became 1,000-watts and by the time the 'Chain Home' radar was playing a decisive role in the Battle of Britain in August, Randall and Boot had achieved a staggering power output of 25,000-watts.

The 1940 cavity magnetron core block, consisting of interconnecting holes and slots (Source: Science Museum London, CC BY-SA 2.0).

Legacy

The resonant-cavity magnetron was one of most revolutionary inventions of the war and helped tip the balance in favour of the Allies. Shortly after the war, American scientist Percy Spencer attached a magnetron to his new oven design and the rest is kitchen history.

As for Mark Oliphant, he went on to play a key role in kick-starting the Manhattan Project, launched the Research School of Physical Sciences at the Australian National University, he was knighted in 1959 and went on to serve as governor of South Australia in the 1970s. He died in 2000, aged 98.

Next time, as WWII approaches Australian shores, we look at the secret Australian research in radar, plus the 'ultra'-secret work carried out in an unassuming Post Office research laboratory in London that produced the world's first electronic computer. ■

There's something just right about Breville making microwave ovens...



DOWNTIME

LEARNING ABOUT OLD MACHINES AND BRINGING THEM BACK TO LIFE VIRTUALLY

MACHINE OF THE MONTH

NEC PC-9800 (1982)

John Knight examines a Japanese 'PC' that was the local Godzilla against IBM's PC.

This month's computer may be unfamiliar, but NEC's PC-9800 series, usually shortened to PC-98, was arguably Japan's most important computer and played an integral part in developing both Japanese language computing and video games. Despite the potential gaming fun offered by this system, there are technical hurdles to be overcome. So after a brief history of the PC-98, let us show you how to emulate the machine as easily as possible.

Development and launch

The PC-98 was a strategically brilliant move by NEC, beating Western competition by exploiting their inept support for Kanji: the complex characters inherited from Chinese, used in any formal writing. NEC recognised the limitations of Western rivals and designed its machine from the ground up to provide solid Kanji rendering and input.

NEC based its new computer around Intel's 8086 processor, but don't be fooled – even though these machines are powered by x86 CPUs (and can run modified versions of DOS and Windows), these are not "IBM-Compatible" PCs. This is a proprietary platform with a different BIOS, I/O ports, graphical system, expansion slots, and even different floppy drives.

NEC wanted its computer to run Microsoft BASIC and be code-compatible with the N88-BASIC of its previous PC-88 line. However, NEC was unable to reach a deal with Microsoft, and simply reverse-engineered N88-BASIC, re-writing it to work on x86 processors.

The first model, the PC-9801, launched in October 1982, for ¥298,000 (worth around \$1,600 then). Its 8086 CPU ran at 5MHz and came with a base 128KB of RAM, expandable to 640KB.

While IBM PCs were still lumbered with four-colour CGA, NEC's µPD7220 twin video chips ran at a much higher 640x400 resolution, with eight colours. However, like IBM PCs, the sound was basic, with only a simple beeper. For storage, customers were offered 8-inch 1.232MB external



■ **CPU:** Intel 8086 @ 5MHz **VRAM:** 12KB & 256 KB **RAM:** 128KB, upgradeable to 640KB **Launch price:** ¥298,000 (approx. \$1,600) **Graphics:** 2 x NEC µPD7220 graphical controllers, 8 colours @ 640x400 **Sound:** PC speaker **Storage:** 8-inch, 1.232MB external floppy drives **OS:** N88-BASIC(86), CP/M-86, MS-DOS, OS/2, PC-UX, Microsoft Windows up to Windows 2000 **Released:** October 1982 **Production:** 1982-1997, 2003 **Worldwide sales:** 18.3 million.

floppy drives, though 320KB 5.25-inch models followed.

Software

The PC-98 was designed to be a work machine and doesn't feature the kind of sprite or blitter processing that action games demanded. The most popular applications were word processors, and the platform also received ports of serious business operating systems, such as CP/M-86, OS/2, and Unix variant PC-UX. Nevertheless, despite its all-business intent, its market share ensured the PC-9800 had a thriving game scene.

Its high-resolution graphics spawned countless interactive graphical novels, dating simulations, and huge amounts of Hentai (cartoon pornography). These games usually featured a point-and-click adventure-style interface, with high-resolution images and occasional animations.

The machine's extra clock speed and memory also made it a great platform for simulators, like *Air Management* (1992), and strategy role-playing games, such as the *Sangokushi* series and *Brandish* games.

The machine also had its share of "bullet-hell" shoot-'em-up titles,

Above: During the 1980s and 90s, if a Japanese person said 'PC', they usually meant one of these, not an IBM-Compatible.

such as the famously bizarre *Touhou* series!

Of course, the main issue is finding games that don't require a working knowledge of Japanese. You can guess your way around simple arcade titles, like the shoot-'em-up *Rude Breaker* (1996). Plus, there were ports of Western games that had an English language option, such as *AD&D: Dragon Strike* (1992), *Sim City* (1990), *Wizardry 3* (1987), and *The Bard's Tale* (1988).

However, there is now a much better source for English speakers (see the box).

Legacy

Although the PC-98 never sold outside of Japan, NEC's computer dominated sales in its home territory, with a market share of between 60-70 percent.

As the x86 architecture continued to develop and evolve, the PC-98 platform evolved with it. Each new generation of Intel processor would bring new PC-98 models. Some machines had Intel CPUs, some had NEC's "V" clone CPUs, and some even had both.

Although the original machine had only simple beeper audio, proper sound cards soon followed. The main sound chip of note is the Yamaha



YOU'LL NEED THIS

A copy of the Neko Project
<http://necchi.kirara.st/>

2203, or "OPN". This chip was quite basic but predated cards like the Sound Blaster or AdLib, and still has fans today.

Data storage was quick to upgrade. Customers soon had the option of 640KB Double Density 5.25-inch drives or 1.232MB High-Density 3.5-inch models. The PC-98's SCSI hard disk interface was much faster than most PCs and was easy to install due to the machine's special C-Bus expansion system.

Over time, the PC-98 series grew closer to IBM's standard and its software library. The factory-installed OS moved away from NEC's BASIC to ported versions of MS-DOS and Windows. Later machines were updated to VGA standard with 256 colours and a 640x480 resolution.

The PC-98 eventually began losing sales to cheaper machines running IBM Japan's DOS/V: a DOS variant capable of rendering Kanji through standard VGA.

However, the PC-98's reign was ultimately brought to an end by Windows 95. Although NEC supported the system, IBM-Compatibles now had proper Japanese support and provided the same essential functionality for a lower price, with much better backward compatibility.

By 1997, the "PC-98" line had devolved into straight IBM-Compatibles, which is where we'll call the PC-98's end. The final machine with a PC-98 badge was released in 2000 with a 433MHz Celeron CPU before the name was discontinued in 2003. By the end of its reign, the PC-98 series had sold over 18 million units.

Emulation

There are a couple of choices of emulator, but the Neko Project is the most used. Linux users can try old packages of the native port "XNP2", but the main Windows version is more up to date and runs well through Wine.

To download the Neko Project, go to the project homepage at necchi.kirara.st. The website is in Japanese but simply click on the link "np2fmgcn.7z" under the PC-98 heading, which will download the emulator.

Extract the package and open the new folder. There will be a collection of executable files: they all basically work and function the same, but emulate different machines – anything with an "sx" in the filename will emulate a machine with an SX processor. We



Above left: *Policenauts* (1994) was a stunning technical achievement, showcasing its moody settings and excellent soundtracks. Left: The PC-98 established Japan's interactive novel style. The thick borders and distinctive font are still used today.

recommend starting with np21nt.exe, but if something doesn't load under one program, try another.

Loading programs

To load a floppy image, the most common format, from the main menu, choose FDD1 > Open, then select your floppy image and click Open.

Many floppy images are in .fdd format, which Neko's file browser won't recognise. When browsing, change your file type from "All Supported Files" to "All Files".

Once your floppy image has been chosen, reset the emulator by clicking Emulate > Reset. Most software should automatically boot.

If your program needs mouse input, middle-click to toggle the capture of mouse input. Alt-Enter will toggle full-screen mode.

There is a chance your games will require 'disk swapping', so remember, there are two floppy menus, FDD1 and FDD2, and an Eject button under each menu.

If you want to try hard disk images, you may have to learn your way around DOS. The "Harddisk" menu is divided into IDE and SCSI menus. IDE hard drive images can be in .hdi, .thd, or .nhd formats. SCSI hard disk images must be in Virtual98 .hdd format. Remember to reset the emulator once your hard disk image is selected.

Fixing fonts

When you first load Neko Project, the Japanese text will be garbled nonsense. To experience this computer properly, you need a Japanese font.

Head to <https://46okumen.com/pc-98-emulation>, to find English patches plus an excellent tutorial for taking Neko Project further.

Download the font file, called FONT.ROM, then from the main menu, click Emulate > Font, and open the font file. When you click Emulate > Reset, any Japanese text should now display properly. ■

ENGLISH TRANSLATIONS

To avoid spending valuable gaming time using Google Translate, some cool internet folks are making English patches for PC-98 games. Two teams are particularly active: 46 OkuMen at [46.okumen.com](https://46okumen.com) and Nebulous Translations at nebulous.group.

They have an impressive list of titles, including *Brandish 2* (1995); cult JRPG favorite, *E.V.O.: The Theory of Evolution* (1990); *Castlevania* clone *Rusty* (1993); and strategy mech game, *CRW: Metal Jacket* (1994). The two biggest games are *Dead of the Brain* (1992), a zombie-apocalypse adventure title; and Konami's cyberpunk thriller, *Policenauts* (1994).

GAMES

Galactic Civilizations IV

You may need a Babel Fish in your ear to understand this game.

■ \$74.99 | PC | galciv4.com



This latest sequel in the long-running strategy series bills itself as the most accessible entry yet. This is true, in the same way that the tail is the most accessible part of a tiger. Stardock's long running 4X series officially has a tutorial now, in the form of a little robot helper accursedly nicknamed 'Space Clippy'. But Space Clippy doesn't help much when a game explains everything as if it's arrived from another dimension.

The irony is *GalCiv IV* is not as obtuse as it seems. It's just terrible at communicating, which means that

enjoying the game at its best involves a lot of false starts. This isn't merely about understanding individual systems: it's also about how key features are presented. Take the game's biggest new idea: sectors. Rather than display its universe as one vast expanse of stars, *GalCiv IV* splits the cosmos into self-contained bubbles, connected to one another by subspace warps (aka space roads). You can play on randomly generated maps with around a dozen of these bubbles, each of which has roughly 30 stars in it. This lets Stardock proclaim *GalCiv IV* to be the largest game in the series ever. Yet while visually impressive, playing at this scale isn't all that fun. 'Galactic'-size games are painfully slow, while ship management becomes extremely fiddly as you're constantly having to zoom in and out to issue orders to individual fleets.

GalCiv is more fun on smaller maps. Not only does the game move faster, with empires forced to rub shoulders more, but the strategic importance of sectors becomes more acute, as those space roads connecting them turn into highways that can be monitored (although not completely blocked) to help defend your empire.

Once you've parsed *GalCiv IV*'s garbled attempts to communicate with you, the universe feels sufficiently weird and ripe

with possibility for a sprawling sci-fi sandbox. Not simply in the various races you encounter, which range from fleshly mantis-like creatures who thrive on oceanic worlds, to armies of sentient robots who don't need food to survive, but also in the many anomalies that you can scan for minor rewards.

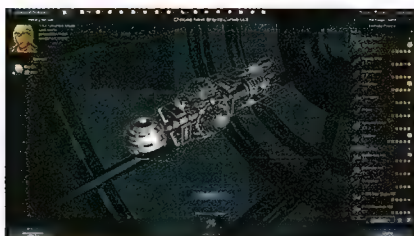
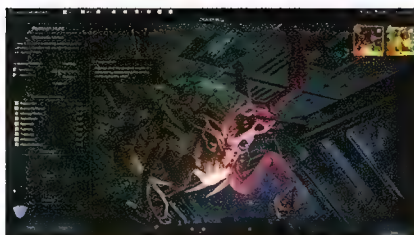
As your empire develops you'll unlock a range of 'executive orders', special edicts that can instantly recruit a new colony ship, boost your income, or reveal a new system on the map. In a game where progress is highly gradual, these quickfire bonuses offer a satisfying immediacy.

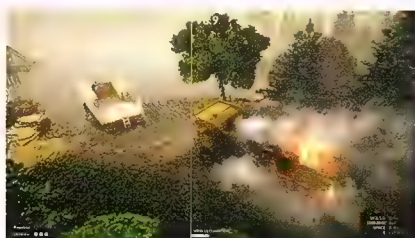
GalCiv IV doesn't have much of a hook compared to other space 4X games. There's little here you haven't seen done better in, say, *Stellaris*, such as the nuggets of narrative tied to anomalies. But then it's got a legacy spanning decades. It doesn't need your approval. It's *GalCiv*.

A vast and dependable grand space strategy. But there's little here that's radical, and expect to meet it halfway.

Rick Lane

★★★★☆





TEARDOWN

Tearing down voxelated worlds never gets old.

■ \$31.90 | PC | teardowngame.com

It would be so, so easy to write off *Teardown* as just a tech demo. A simple framework of maps, tools, and missions built to show off developer Dennis Gustaffson's incredible voxel destruction technology. But over its 18-month stretch in Early Access, *Teardown* has proven itself not only a stunning display of technical prowess, but also a bloody good little heist-'em-up, and the most creative sandbox platform since *Garry's Mod*.

Teardown is, first and foremost, all about that destruction. It's a game of wooden shacks, concrete walls, metal catwalks, and plaster corridors – all of which respond appropriately to being wailed on with a sledgehammer. Despite its blocky appearance, *Teardown*'s worlds break in wonderfully convincing ways. Metal pipes bend when supports are removed, while plaster walls chip away to expose sturdier brickwork, kicking up dust as they crumble.

Teardown's genius, however, is in how it brings method to this madness. The game's campaign tasks you with a series of destructive heists to pull off with a limited set of tools. As a campaign, *Teardown* is a fun experiment with plenty to prod at, framed by a light-hearted story. The real, enduring lifeblood of *Teardown* can be found in its modding community, which has

exploded since the game's Early Access debut. Tired of its nine maps? There are dozens, if not hundreds more on the Steam Workshop. A sledgehammer is fun, but why not go to town on these new wrecking spots with laser rifles, miniguns akimbo, or portable black holes?

The only real shame is in *Teardown*'s complete lack of multiplayer. While I can appreciate the programming nightmare that must come with trying to sync thousands of exploding voxels across multiple clients, it's all too easy to imagine the kinds of new, impromptu games that could spawn from *Teardown*'s foundations. Because those foundations really are incredible. *Teardown* isn't just a tech demo – it's a window into a world where game worlds only became more dynamic, more physical, more breakable. *Teardown* is a game that's excited about its own technology, and wants to show you all the ways it can break stuff.

Teardown is an endlessly delightful destruction sandbox that modders and I can't seem to get enough of.

Nat Clayton

★★★★★

GIVE UP THE GHOST

The afterlife is full of puzzles.

■ Free | PC, Mac | gate.itch.io/ghost

Ghost doesn't boast about its intricate puzzle boxes, but they're some of the most original I've come across. There are often a lot of tools in play, but they're introduced at a manageable rate, and come together in a careful way, with every icon being legible and easily distinguishable in the game's low-res environments.

One of my big stumbling blocks with puzzle games is the amount of information I'm expected to store in my head, but *Ghost* is considerate enough to present as much information as possible within the actual game. I can see the outcome of many actions, without having to test them over and over. Somehow, it's not visually overwhelming as a result.

There really isn't much to criticise about *Ghost*. I suppose the ghost theme is under-explored – you can't actually do any ghostly things, like float over gaps or through solid objects, so I was a bit confused until I realised it was just for show.

This is rare puzzler that meets me halfway, while still offering the devious challenge I'm looking for.

Some seriously smart ideas, and a huge heap of puzzles, presented in an elegant fashion.

Tom Sykes

★★★★★



ORBLES

They might be giants in this novel RTS.

■ Free | PC, Mac | bippinbits.itch.io/orbles

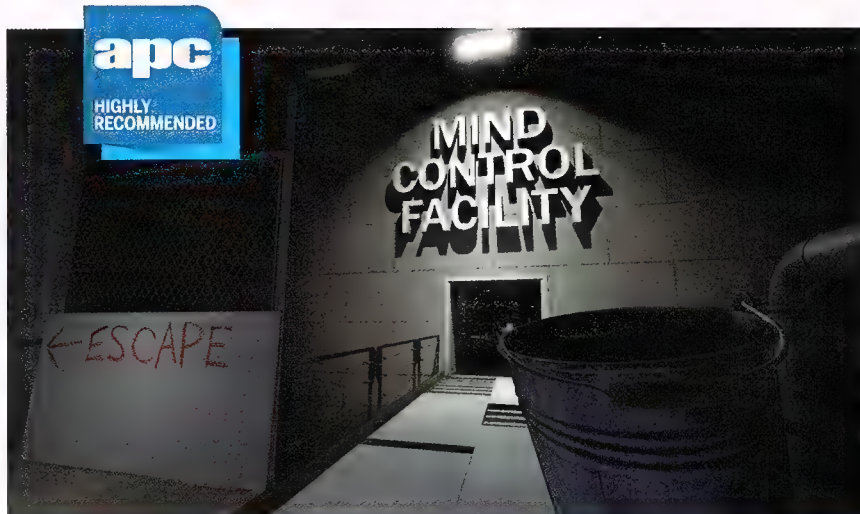
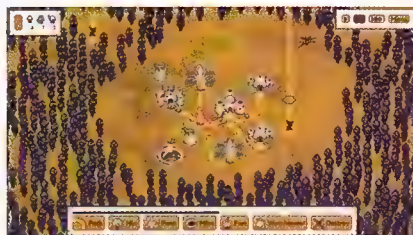
In peculiar RTS *Orbles*, you're not trying to beat another faction operating with the same tools as you. No, your enemy is a horde of giants, advancing upon you from every direction. As the giants constrict the map, they will also demolish any of your structures standing in their way. On a fixed map, you have to build up your little town so that you have enough workers to gather food and metal, and warriors to thin the encroaching hoard. All with the ultimate goal of acquiring three shiny Solar Orbs, which are spread out in a triangular fashion around the map.

Unlike most RTS workers, the humanoid orblings will only walk on set paths. You need a path between the farm and the hut, to turn food into orblings, and paths between the mine, town centre and fortress to turn those orblings into warriors. It's an extremely tough challenge. I do like the ideas in evidence here, I just wish there were some game customisation options as those ideas deserve room to breathe outside this inflexible scenario.

A nice concept, but oh my is it tricky to master.

Tom Sykes

★★★★☆



THE STANLEY PARABLE: ULTRA DELUXE

Buckets of new features.

■ \$34.95 | PC, PS4/5, XBOX/S, Switch | stanleyparable.com

I've never given much thought to the 'skip dialogue' button in a videogame, but after playing *The Stanley Parable: Ultra Deluxe* I can't stop thinking about it. The button is just one of several new features explored in the "expanded reimagining" of 2013's *The Stanley Parable*, which once again turns the act of playing a game into a hilarious, surprising and thoughtful examination of games and game development, players and player choice, and yes, even simple buttons.

It's not just a remaster, though the original game has been faithfully rebuilt in Unity. You can play through it once again as office worker Stanley, who realises he's the only one in the building and sets out to discover why while a gentle storybook-style narration guides him through the empty corridors and rooms. Once again, the simple act of disobeying the narrator and making your own choices leads to numerous branching paths, a range of reactions from the narrator, multiple endings and the pure joy of doing something unexpected and discovering the game fully expected you to do it.

But at some point while replaying the new version of the old *The Stanley Parable*, the new content begins to intrude. It's not a subtle introduction – a door labelled New Content appears in the familiar office corridor you've walked down a dozen

times already. Step through it and a bunch of new features are trotted out.

Developer Crows Crows Crows has done a brilliant job anticipating anything and everything a player might think to do while playing. There's so many new surprises in *Ultra Deluxe* – I've played it for ten hours and I'm fairly sure I still haven't uncovered all its new tricks and treats. As with the original, there are a few patience-testing moments where the narration carries on just a bit too long. But mostly it's a delight, an adventure full of fun surprises, meta-humour, and commentary on games and how we play them. Certainly nothing a 'skip dialogue' button would improve.

A delightful update that fills the original game with more humorous and thoughtful rabbit holes to get lost in.

Christopher Livingston

★★★★☆



ROGUE LEGACY 2

Joins its forebear in the roguelite hall of fame.

■ \$35.95 | PC, XBN1/X/S | roguelegacy2.com

In this sequel to the 2013 game, once again you step into the shoes of a randomised hero tasked with navigating the levels of a procedurally generated castle. Said castle is a gruelling gauntlet teeming with tough enemies to defeat, tricky obstacles to overcome, and valuable gold to steal. If, or more likely, when your hero reaches the bottom of their health bar, you'll swiftly find yourself in the footwear of their descendant.

At the start of each run, you're given a choice of three characters from an array of unlockable classes. Old favourites such as the Knight and Barbarian are mixed with exciting new options like the Gunslinger and Valkyrie. Classes now come with their own unique stats, weapons, talents, and passive abilities, making each feel distinctly different from the last.

However, some classes are considerably more effective than others, and I found myself passing up the less useful ones after giving them a few tries. For example, a lack of multidirectional aiming for spells meant the mage class sat on the bench for most of my time with *Rogue Legacy 2*.

Threatening you along your journey is a relentless horde of enemies. Some fill the screen with deadly projectiles, while others want nothing more than to whack

you with a powerful melee strike. Enemies aren't your only worry; levels are a platforming labyrinth, filled with hazardous obstacles like spiked pits and flaming traps which require careful timing and patience to overcome. It's fast-paced and incredibly fun, and despite being bested many times, I couldn't wait to jump back in to have another go.

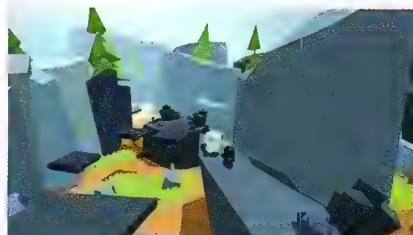
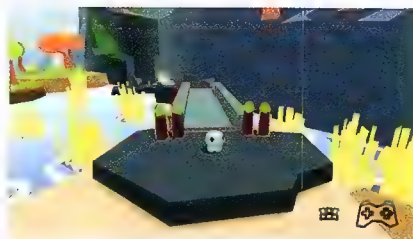
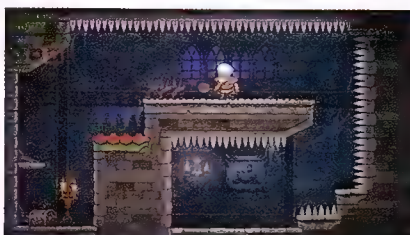
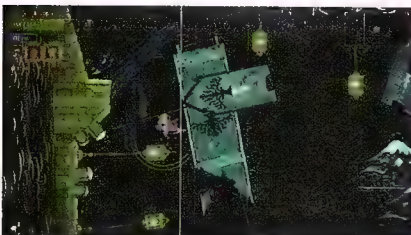
The most significant addition to *Rogue Legacy 2*'s family-orientated antics is the heirlooms. Once obtained, these helpful trinkets unlock traversal abilities, including a double jump and an aerial dash that allow you to reach new locations.

Cellar Door Games' latest stands among the finest in a genre it helped define. The demanding yet endlessly entertaining gameplay, fuelled by a rewarding progression system, is as absorbing as it was the first time around.

*This sequel is a sublime addition to the *Rogue Legacy* family and one of the best roguelites I've played so far.*

Anne-Marie Ostler

★★★★★



PEBBLE

This 3D platformer is as humble as its name suggests.

■ Free | PC | wardius.itch.io/pebble

I admire the unassuming nature of the protagonist in *Pebble*. You are literally a pebble, with only a pair of boots to add an element of anthropomorphism. Everything about *Pebble* is minimalist, and that's refreshing in a genre stuffed with collectibles and radical marsupials. Here's a small, sunny world for you to explore, while enjoying a relaxing soundtrack.

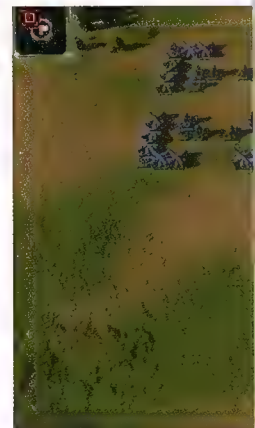
Pebble does have one idea – any more would be overkill. The little pebble can acquire green gemstones, attaching them to its body for later use. You'll come across inactive platforms that will accept the gemstones as currency, allowing you to unfurl bridges or shift floating platforms so you can use them. The clever bit is that you will often need to circle back to retrieve the gemstones later on, recycling them for use in subsequent puzzles.

The cosy exploration of the early game transitions to precision, timed platforming that feels inelegant by association, thanks to a camera that sometimes parks itself in unhelpful places.

A bigger game with smarter puzzles would be more welcome.

Tom Sykes

★★★★★



Left: Look at all those little guys! Adorable.

Above: This is what peak graphical performance looks like. Or what it looked like in 2007, at least.

Right: The setting is a thousand year conflict dubbed The Infinite War. Take that, Warhammer 40K.

GAME CHANGER

Supreme Commander

The demanding RTS runs well on modern machines. By Luke Winkie.

■ Release: February 20, 2007 Developer: Gas Powered Games Publisher: THQ Link: bit.ly/3vfgWbJ

There is no high quite like the emasculated agony of graphics envy. It was 2007, I was 16 years old, and still fully bound to the limitations of the Xbox 360 and PS3 in the bedroom. The hand-me-down laptop whirring on the desk could barely handle *Battlefield 1942*, much less the relentless tempo of speedy processors dutifully obsoleting the seventh generation of home consoles. Still, I voraciously tore through the games press, reading up on the mouthwatering vistas that were enthusiastically unavailable on a Dualshock, essentially as a way to torture myself. The primary object of my obsession? *Supreme Commander*.

Gas Powered Games' watershed RTS arrived with exactly one selling point; this thing was a beast, and you should be jealous if you couldn't run it. And so, I binged the 360p E3 preview footage of *Supreme Commander* on my sad, dinky laptop, which seemed to

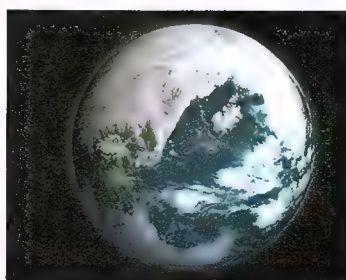
wheeze and gag at the mere sight of all of the quicksilver troops swarming over the skirmish fields. So close, and yet so far.

It sounds strange now, but there was a time in the mid-2000s where every GPU benchmark was set by the latest round of RTSes – much in the same way that Sony shows off new Playstation tech with rain-slicked Lamborghinis in a sumptuous *Gran Turismo* suite. If you grew up almost exclusively on consoles like I did, you became accustomed to this beautiful heartache when the PC class laps whatever third-party ports emanating from the family TV. 2007 was the apex of the cycle. Here I was stuck with *Mercenaries 2* while the adults in the room ran circles around us with the finely modelled tools of destruction deployed by Crytek and Relic. As I soaked up those titanium-plated mechs and supersonic bombing runs of the gorgeous *Supreme Commander* dystopia, I made a

private pact that should be familiar to the many other young men reading this story. Someday, I too will dump a ton of my hard-earned income into a top-tier gaming rig, and then I'll never be left in the dust ever again.

It goes without saying that the Alienware Aurora below my desk is more than capable of running *Supreme Commander* in 2022. This machine just chewed through *Elden Ring*, *Battlefield 2042*, and *Forza Horizon 5* without a hitch; I put my money where my mouth was. There is something darkly satisfying about returning to a videogame that was once a GPU showcase after much time has passed – much in the same way a crosstown rival relishes the chance to get their revenge on a formerly great sports team. *Supreme Commander* creaks out of my Steam library with none of the expected orthodoxies of the last 15 years. The resolution sputtered to fit the aspect ratio of a widescreen





monitor, any stray alt-tabbing was guaranteed to lead to a lock-up, and I actually needed to slow down my mouse cursor speed to molasses levels in order to cut down on the 120fps whiplash. At last, after the humiliation of my Xboxified youth, revenge was finally mine. But at what cost?

Blowing off the dust

Gamers have rarely asked for much from a graphical standout beyond their aesthetics. Simply watching *Supreme Commander* run was half the appeal in its heyday, so I was

not surprised that the campaign offered me a few paragraphs of sparse flavour text before dumping me into the barren grasslands crucial to the RTS experience. The missiles are supposed to do the heavy lifting, right? So, a few power generators and mass extractors later, the war machine was up and running, and I was ready to make good on a derelict promise I made with my teenage self. But just look at what time hath wrought. The starchy textures of the earth stretched out in every direction, featureless and bland,

almost *Cruelty Squad*-like in its disorienting uniformity. The tank-shaped blobs that steadily pumped out of my munitions factory looked better, but not by much. They encircled the rival base and peppered it with raw, pixelated smoke and fire. It would've been right at home on the App Store, advertised in the bleakest corners of the web.

How can that decay happen so quickly? *Supreme Commander* hasn't even celebrated its 20th anniversary, and yet its prime attribute has been absolutely obliterated by the PC power curve. A chill ran up my spine as I realised that this fate has probably befallen all of its peers; after all, it's been a while since I've seen *Crysis* up close, too.

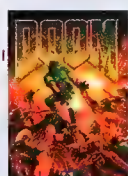
Maybe this is a fitting fate. I have a faint memory of RTS diehards dismissing *Supreme Commander* while it was still at the peak of its influence, complaining that the game was more sizzle than steak compared to its deeper, but considerably uglier peers (after all, *Company of Heroes* came out a year

Above: I miss good RTS campaigns.

"The resolution sputtered to fit the aspect ratio of a widescreen monitor"

THE BEST GAMES YOU CAN'T RUN

A brief timeline of all the games we upgraded our PCs for.



DOOM 1993
Yes, *Doom* was a beast long before we were running it on iPhones.



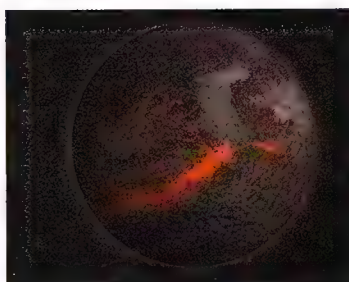
DAIKATANA 2000
If only the specs matched up with the gameplay.



CRYSIS 2007
Some say even the beefiest machines still shudder at the sight of that jungle.



RISE OF THE TOMB RAIDER 2015
Were the ponytail physics worth it?



before). I would never claim to be an expert of the genre, but after surviving the temporal horror of the boot-up, where it becomes excruciatingly clear that we're all deteriorating right alongside the video games we used to play, I can say for certain that Gas Powered Games got a bad rap. The studio was clearly in love with their tech, and gave the player ample opportunity to fill the screen with as many troops as possible. It's a philosophy that produced a gaucheness that likely turned off

some of the traditionalists. My favourite quirk? Anyone can send an engineer into a blazing firefight where it can happily plop down a fresh manufacturing operation totally divorced from any adjacent resources or supply lines. Are you being victimised by bombing raids? No problem, just encircle yourself with a battalion of flak cannons anywhere on the map. These are the sort of firefights dreamt up by the most perverted Warhammer sickos; an endless tide of shocktroopers born

Above: The game was a spiritual successor to *Total Annihilation*.

into battle and living five-second lives.

Step on the gas

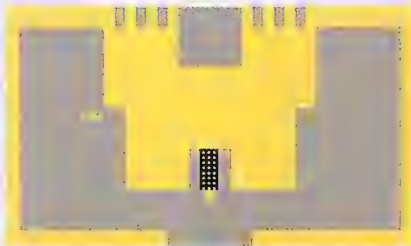
So yes, *Supreme Commander* is a little bit silly, but only as a way to summon up the primal joys of real-time strategy. If *Mortal Kombat* is a grotesque celebration of 100-hit combos and old-school arcade depravity, then this studio wished to celebrate the full-scale pyrotechnic throwdowns that define our favourite tactical successes. I never really loved

CUTTING EDGE

To think that these games once represented the apex of graphical fidelity.



VIRTUA FIGHTER
Four, maybe even five polygons of action!



ADVENTURE
Say what you will, but that castle texture is still great.



FEAR
Never tell anyone under 20 that this used to scare you.



Above:: Maybe that's just what ground looks like after a thousand years of warfare.
Right: The sheer scale is still pretty cool to behold.



managing an economy in the first place, and slamming up against the guardrails as I was trying to produce a legion of Mutalisks in various harebrained *StarCraft* schemes. Gas Powered Games was entirely disinterested in beating around the bush, and instead allowed players to prioritise whatever warfighters they want so long as the energy ratio is pointing up. Perhaps that's why there's still a small, dedicated *Supreme Commander* community crashing into each other on the desiccated servers. I became absolutely terrified to play them the deeper I got into the campaigns. There are so many bizarre strategic curveballs in this game, and that has undoubtedly consolidated into an abstruse meta that would leave me pantless and sobbing against even the most casual opponents. You really can build anything, which means you need to be scared of everything.

Campaign trip

That was fine with me though, because it's been years – maybe even decades! – since I sat down with an old-fashioned RTS solo story. You know what I'm talking

about; disembodied voices hovering over NPC megabases, a foreboding mission timer in the corner of the HUD counting down to a game-losing assault, the developers desperately squeezing any potential varietal out of what will always be a fairly straightforward premise (destroy the enemies halfway around the map. Leave no survivors. Prepare for a crippling counterattack). It all took me back to a happier place. In one level I was supposed to use an air transport to hoist a crucial unit over some distant mountains that bracketed the map into two theatres. First though, I needed to rout the mobile anti-air cannons patrolling the no-man's land. Out came the tanks, blasting through the heavy steel, avenging all of my doomed pilots. That's the sweet spot for me: an RTS objective that doubles as a weird, rock-paper-scissors logic puzzle. If it's been a while since you've indulged in that erstwhile gaming pleasure, then I highly suggest coming home to *Supreme Commander*.

Honestly, that was my primary takeaway from the game, as it slowly morphed from an artefact of GPU lore to, well, an ordinary piece

of outmoded software. This industry is cruel to its ancestors, especially those that once annihilated the motherboards of yore. In fact, I'd reckon that most people's relationship with *Supreme Commander* was one of inaccessibility – a faint idea of wondrous gaming superiority, something to flaunt over the plebs. All of that macho posturing has gracefully evaporated, leaving behind a very good RTS with a lot of neat systems, coming off more like an underdog indie project rather than the harbinger for a new era of PC engineering.

In 2022 *Supreme Commander* is ugly, janky, and hopelessly out of step with modernity, but at least the giant robots explode in a nuclear fireball when they're killed. It was awe-inspiring in 2007, and now comes off kind of quaint – videogames in its primal adolescent period. Surely it is only a matter of time before another high-budget opus laps whatever I've got simmering under the hood, provoking a stressful search for a few extra gigs of RAM. That trick will keep working on me forever, and I'm all the happier for it. ■



RETRO

THE 30-YEAR REVIEW:

Amstrad Notepad NC100

Having waited 30 years to get his hands on an Amstrad Notepad NC100, David Crookes wonders if this low-cost computer could still fit into his daily work routine today.



Alan Sugar made a startling confession when writing the opening text for the Amstrad NC100 Notepad's manual: "I am embarrassed to say that, as the chairman of one of Europe's largest manufacturers of computers, I have never been able to use one!"

It was 1992 and Amstrad was indeed a huge player in the still fledgling computer market. Having entered the industry with the CPC 464 in 1984, it had introduced the popular PCW range, bought rival Sinclair, got burned in the video-game industry with the GX4000 console and launched affordable PCs including a successful series of portables.

The NC100, however, encapsulated everything Amstrad desired. The company was always talking about creating tech that focused less on what was inside and more on what could be achieved at the lowest possible price. And in making the Notepad, it had a computer that was vastly cheaper than a laptop yet provided the basics of computing – the stuff the company reckoned 80 percent of the population wanted.

Similar to the Cambridge Z88 released in 1987, it was an A4-sized, slimline notepad computer based

around the ageing Z80 processor used in the CPC and PCW. Boasting just 64K of RAM and 256K of ROM, it had a letterbox LCD screen displaying 80-character columns by eight rows. It also came with a guarantee: "If you can't use this new computer in five minutes," Sugar wrote, "you'll get your money back."

Now, Amstrad is not going to honour that promise today, not least because the company became defunct in 2010. Not that I'd pester for a refund anyway. I snapped up my NC100 for a bargain \$50 on Facebook Marketplace just to see if it could fit into the general workflow of a modern-day journalist, and it really did take me only a few minutes to get to grips with it.

Okay, I lie slightly. After slipping the NC100 from its bundled, soft protective case, I flipped it over, inserted four AA batteries and switched it on, only to be confronted by an error message telling me the lithium battery was low. Since it's used to keep your work safe when there's no other power source, it needed to be replaced with a CR2032 type battery (the NC100 won't function without one), but at least Amstrad

Above: After 30 years, the Notepad NC100 looks dated yet charming.

said it should last five years.

Swapping the batteries proved an easy enough task, although I needed to clean the contacts before the error message disappeared. With that done, I could progress to the next stage of figuring out how to use the computer itself, which, I surmised from the very start, would involve pressing the colourful keys located on the bottom row of the otherwise dark charcoal grey keyboard.

Evoking past glories

As a fan of the CPC 464, I felt an immediate pang of nostalgia. If you've ever seen Amstrad's debut machine, you'll know it has a scattered selection of red, green and blue keys, but the NC100 went one better by introducing yellow – a sure indication of progress. This big yellow button is labelled Function and when pressed in combination with the other trio of colours, it launches one of the three main apps.

Of those, the calculator is the most basic. You use a set of keys imprinted with green numbers to perform simple arithmetic. This is no scientific calculator, that's for sure. The diary/clock/address book feature is also merely functional.



Above: The coloured keys of the NC100 hark back to the CPC 464.

You can create a database of addresses, view a calendar and create diary entries while also setting an alarm and time zones – all things your phone can perform far more adeptly today.

Instead, your focus will be squarely on the built-in word processor which, as distraction-free text editing goes, is more than up to modern-day tasks. Not only does this make good use of the NC100's excellent keyboard (more on that later), it also has a few neat tricks up its sleeve.

Making some notes

Again, there's a CPC flavour here thanks to the NC100's use of a capable program called Protext. It was first developed for the 464 in 1985 by a company called Arnor before being sold on other platforms including the Amstrad PCW, PC, Commodore Amiga, Atari ST and the Acorn

Archimedes.

Amstrad commissioned a special version for its Notepad and, as soon as it launches, you're offered the choice of starting a new document, seeing a list of stored documents or sending a file to a printer. Once again, it's a matter of hitting one of those coloured keys to make your choice. It all seems so immediate.

Upon starting a new document, you're asked to input a filename. You're then told to "start typing new text here" – a tad basic, perhaps, but the NC100 was designed to appeal to novices, after all.

Here, however, I ran into my first major problem. The screen isn't backlit and it suffers from glare, which means the text appears faint by modern-day standards. Even though I jiggled around with the contrast control on the right of the machine, I still found myself

staring closely at the screen to make out the words.

Shining a desk lamp directly over the screen helped enormously (next stop, the optician!), and propping the computer on its flip-out legs also placed the screen in a slightly more comfortable, raised position.

This enabled me to properly get to grips with the word-processing features, which, given this computer primarily functions as a way of pushing text around, greatly impressed me.

As well as being able to type over existing words, restore deleted text, add accents and use special characters, it's possible to draw boxes, move and copy blocks, and display underlined, italic and bold text.

Page numbers and breaks can be inserted, there's a find-and-replace feature, and you can also alter the page layout.

Many of these features are listed directly beneath the screen together with the keypresses needed to action them. You can also check the word count and spellcheck a document using the configurable built-in dictionary of 48,000 words. But what really turned my head, aside from

"Boasting just 64K of RAM and 256K of ROM, it had a letterbox LCD screen displaying 80-character columns by eight rows. It also came with a guarantee: "If you can't use this new computer in five minutes," Sugar wrote, "you'll get your money back.""

Left: These keys open the main apps, but there's also a Secret Menu.





Above: Go online to find programs for the NC100 – or code your own!

"A lot of time was spent developing a comfortable keyboard, complete with normal-sized keys. It's an absolute joy to use"

powerful mail-merge facilities, was the inclusion of macros, something that had been available on previous Protex versions and has since been adopted by other word processors.

In this case, you simply tap the Secret Menu button (yes, there is such a thing), whereupon you can choose to record a sequence of keystrokes that can then be

reproduced by prodding at a couple of keys. There's another option to display all the ones you've created, along with a selection added by the makers. And the back of the manual includes a whole host of other editing commands and macro definitions. Arnor did a fine job here.

Practical concerns

There's also the minor matter of how large your document files can be. With just 49K available for all your data, you're not going to be knocking out a novel unless you expand the memory using an SRAM PCMCIA card. These go up to a whole 1MB. The challenge is to find the cards for sale, but if you manage to do so they fit into the memory card slot on the left-hand side of the Notepad, allowing

documents to be automatically stored. Again, it shows great foresight on the part of the Amstrad "boffins", the name given to the company's engineers by their former boss.

At this point, with Sugar's simple computer suddenly feeling more complex, you can only admire the effort put in by those boffins. They could have produced a cheap and cheerful computer that merely covered the basics, yet the more in depth you go, the more you see how passionate the team must have been.

One thing's for sure, a lot of time was spent developing a comfortable keyboard, complete with normal-sized keys that are perfect for people with fat fingers like your correspondent. It's an absolute joy to use.

Not only could you spend many hours on your travels tapping away without feeling fatigued, you don't need to worry about running down the batteries in double-quick time either: I squeezed 24 hours out of my set. MacBook owners eat your heart out. You can also power the machine from the mains, but make sure the barrel of the mains adapter plug is positive otherwise you'll blow its internal fuse.

The NC100 has two sockets at the back: a 25-pin Centronics parallel port into which you can insert an older, compatible printer (should you still be able to find ink) and a nine-pin RS232 serial port.

The NC100 doesn't have a floppy disk drive and, when it launched, the USB standard was still four years away from being released, so these ports are the gateway to the outside world.

Since the NC100 has built-in communication software, you only need to find the right cable and an app on another machine that will let you receive the document you send. The manual suggests you can connect the NC100 to a serial port on your main machine but you're unlikely to have this today.

Instead, I bought a USB to RS232 cable from Amazon, making sure the serial end was female. Once plugged into the NC100 and a Mac, I downloaded a driver (www.prolific.com.tw/US/index.aspx) and the free SerialTools app from the App store. Windows users could try PuTTY (tinyurl.com/APC5o8ST) and the end result will be the same.

By ensuring the Baud Rate was 9600, Bits were 8 and Stop Bits 1, it was a simple case of listing my stored documents, finding the one I wanted to send, pressing the Secret Menu key, selecting "T >> Transfer" and hitting "S". It worked a treat, sending my words to my main computer, thereby making the NC100 a viable word-processing device even in 2022.

Down to basics

But it doesn't stop there. Delve deeper and you'll find you can



password-protect data you'd like to keep secret. You'll also find a version of BBC BASIC that really opens up the possibility of expanding the NC100's capabilities, though the manual's suggested type-ins didn't exactly float my coding boat (there's a reaction time tester, musical organ, scientific graph plotter and analogue clock). However, these are included as a way of introducing users to the BASIC programming language and the excellent manual does a great job explaining how the code works and the various commands you can use.

Even if you can't be bothered getting your fingers dirty with a spot of programming, you can still discover the endeavours of others. One of the best online resources is Tim's Amstrad NC Users Site (ncus.org.uk), which has a fine selection of games, applications, utilities, procedures and novelties. Keep an eye on the NC Facebook group, too ([facebook.com/groups/NCusers](https://www.facebook.com/groups/NCusers)). Like Tim's website, it answers a host of common problems and queries.

Among the apps are an accounts package that enables you to track your income and expenditure, a book-indexing system, a simple drawing app, a memory checker and a document merger. There's also a BBC Micro to NC program converter, plus a set of mouse drivers for your BASIC programs.

All of them are free, and half the fun is in exploring what's out there and seeing how far you can push the Notepad. It's clear there are a lot of passionate users, which is all part of the fun of retro machines.

Expanding horizons

More advanced users can even run a version of CP/M, the first universal operating system to gain widespread acceptance. Created in 1974 by Digital Research, it

eventually lost out to DOS but it works very well on Z80 machines (hence why Amstrad bundled it with the CPC 6128 and PCWs). Having CP/M on the NC100 opens up another world of applications and utilities, since it runs most CP/M 2.2 programs.

To use it, you need to download a free version called ZCN (www.ibiblio.org/pub/packages/zcn/) and invest in a PCMCIA memory card. Sadly, without having one to hand, I couldn't check this out for myself.

So, will the NC100 become my day-to-day work machine? In truth, no. Time has moved on, and squinting at a small screen while tapping out thousands of words each week would be a stretch. But I would be more than happy to slip one of these lightweight lovelies into my travel case and enjoy the comfortable keyboard. It would allow me to knock out a bit of prose on the go, safe in the knowledge that the batteries would last the distance.

In fact, I've enjoyed using the NC100 so much I'm already considering upgrading to the



Amstrad NC200. This model, launched in 1993, had a larger, backlit screen that flipped up to provide a more pleasant viewing angle. It also incorporated a spreadsheet, twice as much RAM and a 3.5in floppy disk drive.

A company called Simulant sells a Gotek drive for this computer that swaps out the floppy for a USB flash drive, which would certainly make transferring files much easier – no more need for a cable. But that's something to consider for another day. As it stands, I'm still having fun exploring what else the NC100 can achieve. ■

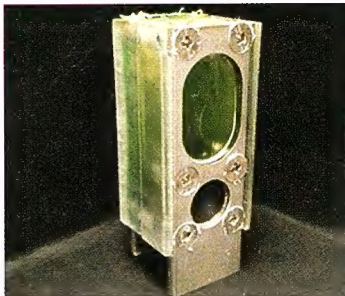
Top: The NC100 has a built-in terminal and can be connected to a phone line or another computer.
Above: The green keys are purely for the calculator and add to the clutter.



Left: The NC200 comes with a backlit screen and a 3.5in floppy slot.

CHIP CHAT

APC REPORTS ON THE UNUSUAL SIDE OF TECH NEWS



THIS ALGAE-POWERED COMPUTER PROBABLY CAN'T RUN *CRYSIS*

It may help wean us off fossil fuels and rare earths, however.

A team at Cambridge University, the Howe Lab, successfully powered a small computer for six months through the energy produced by a colony of photosynthetic algae.

The researchers created a AA battery-sized clear plastic and aluminium enclosure to house the algae and an aluminium anode. The researchers believe the most likely source of the battery's energy output is electrons produced by the algae as a byproduct of their regular processes. The battery was left on a windowsill and was used to power an Arm Cortex-M0+ processor. The processor ran constant calculations to simulate a normal workload, and also recorded the power output of the algae battery.

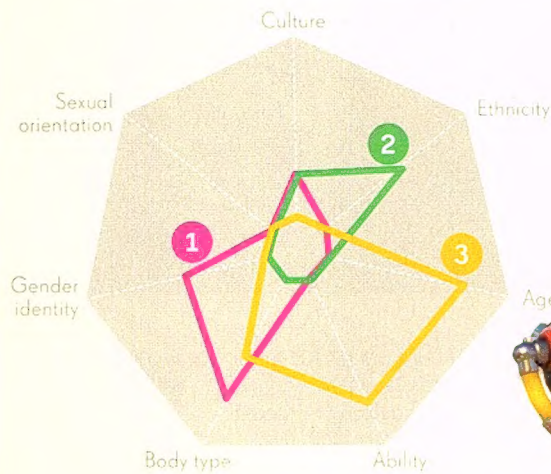


COUNTING IS TOIL

Amazon's smart solution for goldfish attention spans.

Don't touch your face! Wash your hands for 20 seconds! Ahh, the good old days of early COVID. For those that can't count to 20 or make a reasonable guesstimate, Amazon's Smart Soap Dispenser does the counting for you, and will flash its light on the stroke of 20, so you know the job's done. If you're blind and can't see the flashing light, to avoid inadvertently hand-washing for 19 seconds, or 200 seconds, the device is Alexa-connected so it can be set to have 20 seconds of your favourite hand-sanitising beats play to make the whole experience much more fun.

Diversity Space Method



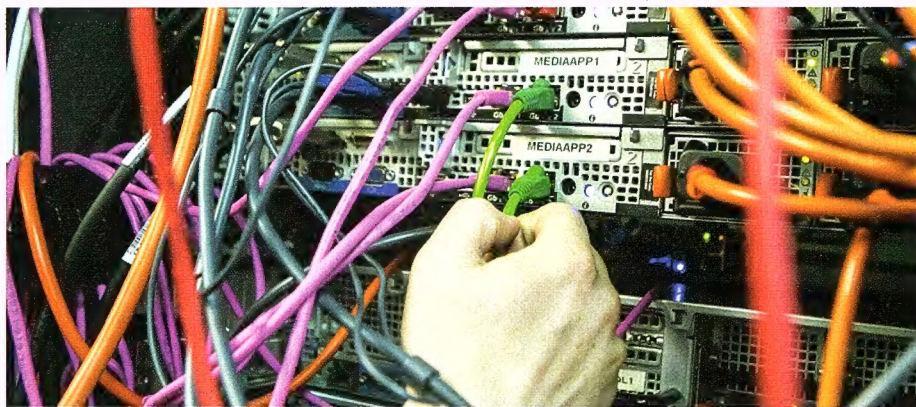
CHIP CHAT

Diversity by numbers

"This has been such a punch to the gut for us."

Activision Blizzard has faced severe backlash after announcing a tool its devs will use to balance diversity in game characters. The Diversity Space Tool was widely criticised online, with many pointing out the bureaucratic oddity of "creating a tool when you could just hire diverse designers and listen to them". The scale has as its zero-point

the typical middle-class white cis male videogame protagonist, but how exactly do you score something like 'race' out of 10? *Overwatch* character artist Melissa Kelly commented, saying, "God I swear our own company tries so hard to slaughter any good will the actual devs who make the game have built."



PIC: Getty

IT ADMIN GETS SEVEN YEARS FOR WIPING HIS COMPANY'S SERVERS

Allegedly felt undervalued after his security warnings were ignored.

An indignant Chinese IT admin, seemingly aiming to prove the lax security his employer had hitherto ignored, proceeded to delete a bunch of vital financial databases, and has subsequently been given seven years in prison as a result. Han Bing destroyed four different servers, salting the earth so nothing could be recovered, and

grinding the company's 12,000-employee operation to a halt.

Colleagues of the rogue admin have suggested that the reasoning behind his deletion of company records was down to the fact he discovered the security of the financial system was compromised, and his concerns were ignored.

Advanced Business Network Multi-WAN Solution for NBN Fast, Secure & Reliable

DrayTek
Aust & NZ
www.draytek.com.au



Vigor3910

Enterprise Level VPN Concentrator with
10Gb High Speed and 1.2GHz Quad-Core
Processor



500x

VPN

techradar pro



Octuple-WAN broadband router with 2 x 10Gb SFP+
Fibre WAN/LAN Slots, 2 x 2.5GbE WAN/LAN ports,
and 4 x fixed GbE LAN ports, SPI Firewall; supports
500 x VPN tunnels including 200 x SSL-VPN tunnels

- 2 x 10G/1G SFP+ Fibre configurable WAN/LAN Slots
- 2 x 2.5G/1G/100M/10M Ethernet configurable WAN/LAN ports
- 4 x 1G/100M/10M Ethernet Configurable WAN/LAN ports
- Multi-WAN Load Balancing & Failover
- 4 x 1G/100M/10M Ethernet LAN ports with 1 million NAT sessions
- Quad-Core CPU with 9 Gbps NAT throughput
- 500 x VPN tunnels (including 200 x OpenVPN/ SSL-VPN tunnels) with most security protocols
- 1 x RJ-45 console port
- Fast VPN throughput, VPN Load Balancing, Failover, and backup for site-to-site applications
- 50 x VLANs for secure and efficient workgroup management
- High-Availability (with CARP) ensuring 24/7 system uptime
- Object-oriented SPI Firewall
- Multi-subnet WAN/LAN through 802.1Q
- IPv6 & IPv4
- Bandwidth management
- Supports VigorACS 2 & VigorACS 3 Central Management Software for remote management
- SD WAN capability when used with VigorACS 3
- Supports Central AP Management (up to 50 Vigor Access Points)
- Supports Central Switch Management (up to 30 Vigor Switches)
- Rack-mountable
- 2 years back to base warranty

Vigor2962 Series

High Performance 2.5GbE Multi-WAN
Broadband VPN Routers with GbE PoE
LAN Ports



200x

VPN

Vigor2962P

techradar pro



Multi-WAN broadband routers with 1 x 2.5GbE WAN/LAN
port, 1 x 1GbE combo SFP/Ethernet WAN/LAN port, 2 x
GbE WAN/LAN ports, 2 x fixed GbE LAN ports, 4 x Gigabit
PoE LAN ports with a total power budget of 65 Watts
(Vigor2962P), SPI Firewall, and 200 x VPN tunnels including
50 x SSL-VPN tunnels

- 2 x GbE configurable LAN/WAN ports *
- 1 x 2.5GbE configurable LAN/WAN port *
- 1 x 1GbE combo SFP Fibre / Ethernet configurable WAN/LAN port
- Multi-WAN Load Balancing & Failover
- Up to 5 x Gigabit LAN ports with 300,000 NAT sessions
- 2.2 Gbps NAT throughput
- 4 x Gigabit PoE LAN ports with a total power budget of 65 Watts (Vigor2962P)
- Object-based SPI Firewall, Content Security Management (CSM) and QoS
- 200 x VPN tunnels (including 50 x OpenVPN/ SSL-VPN tunnels) with comprehensive secure protocols
- Up to 1 Gbps site-to-site IPsec VPN throughput
- Fast VPN throughput, VPN Load Balancing and backup for site-to-site applications
- 20 x VLANs and LAN subnets for secure and efficient workgroup management
- IPv6 & IPv4
- High-Availability (with CARP) ensuring 24/7 system uptime
- Bandwidth management
- Supports VigorACS 2 and VigorACS 3 Central Management Software for remote management
- SD WAN capability when used with VigorACS 3
- Central AP Management for up to 50 Vigor Access Points
- Central Switch Management for up to 30 VigorSwitches
- 2 years back to base warranty

* Switchable WAN/LAN Port, up to 2 simultaneous WANs



i-LAN Technology Pty Ltd trading as DrayTek Aust & NZ

www.i-lan.com.au

(02) 9838 8899

sales@i-lan.com.au

www.draytek.com.au

© Copyright 2022 i-LAN Technology Pty Ltd. All rights reserved.



intel
CORE™
i9

BUY NOW
>>> WWW.MSI.COM

EOFY 2022



SCAN HERE OR

LEARN MORE
AT MSI.COM



SAVE UP TO \$1500 AUD

Powered by Intel® Core™ i9 Processors.

While stocks last. Ends July 31st 2022. T&Cs Apply.

msi®